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Parasitic Fauna of Blue Halibut [Reinhardtius hippoglosoides (Walbaum, 1792)] from Selected Regions of Species Occurrence

by

Jadwiga Wierzbicka

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Dissertation Presented to Qualify for an Assistant Professorship

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1. INTRODUCTION

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The parasitic fauna of blue halibut (Reinhardtius hippoglossoides (Walbaum, 1792)), one of the more usable species sought for in world fisheries, is not relatively well known. To date, reported findings on this topic have been based for the most part on a small number of examined fish and are therefore not representative.

The earliest data on the parasites of this host come from the Barents Sea (Polyanskii, 1955). This author found only 6 species of parasites in two individuals of blue halibut (1 - Protozoa, 1 - Cestoda, 2 - Trematoda and 2 - Nematoda) when studying parasitic ichthyofauna in this sea area.

Blue halibut is also included in a study carried out by Mamaev et al. (1963) on fish of the family Pleuronectidae from the Northern Pacific. These researchers dissected 13 fish of this species caught in the Kamchatka Zaliv and 7 fish caught in the Avacha Zaliv. They found a total of 21 species of parasites in their research material. Most of them belonged to the class Trematoda (11 species). Moreover, the occurrence of 5 species of Cestoda (3 Nematoda and 2 Acanthocephala) was noted.

A list of parasites of blue halibut from the Atlantic coast of Canada was compiled on the basis of literature and published by Margolis and Arthur (1979). According to this list, only three species of Trematoda and one Nematoda gen. sp. were noted in this region. The aforementioned trematodes Derogenes varicus (Muller, 1784) and Fellodistomum furcigerum (Olsson, 1867) are among the more frequent parasites of many species of marine fish.

Zubchenko (1980) and Reimer (1981) have also published studies on the parasitic fauna of blue halibut from the North Atlantic. The main purpose of Zubchenko's research was to compare parasitic fauna of the fish Pleuronectidae and Anarhichadidae from fishing grounds lying between the north-eastern coast of Newfoundland and Baffin Island. The material contained here relating to blue halibut was limited to only 20 individuals in which the author noted the occurrence of 16 parasitic species from various systematic groups (from Protozoa to Crustacea inclusive).

A more detailed study of blue halibut based on a quantitatively larger amount of material was presented by Reimer (1981). He studied 55 fish from the Davis Strait and 73 individuals caught near Bear Island. His publication contained topics similar to some of the problems touched upon in this study. The author noticed certain differences in the parasitic fauna of this host in the bodies of water studied; he found 13 species in the Davis Strait and 9 off Bear Island. The parasites he found belonged to the Trematoda, Cestoda, Nematoda, Acanthocephala and Crustacea. Reimer did not include the class Protozoa in his publication, however. 6/

Wierzbicka (1987) presented results of initial investigations into the parasitic fauna of blue halibut from the fishing grounds of Labrador in the form of a short report.

In addition to the studies enumerated above, which deal with parasitic fauna of blue halibut in a general manner, there have also been other detailed studies. One of these was carried out by Kabata (1979); this deals with the crustacean Neobrachiella rostrata (Kroyer, 1837), among others. His studies showed that this parasite occurs only on white halibut (Hippoglossus hippoglossus). This does not conform to the results of earlier scientists who also found this crustacean on blue halibut. Rokicki (1982) studied parasitic crustaceans of this host from the fishing grounds of Labrador. He studied 922 individuals

of blue halibut and found N. rostrata and two other species - Sphyrion lumpi (Krøyer, 1845) and Aega psora (Linnaeus, 1758), both of which occurred sporadically in his material. A study by Kovaleva et al. (1983) devoted to protozoa (Myxoproteidae fam. n.) parasitizing in marine fish has also appeared in recent years. These authors describe, among others, a new genus and species - Schulmania quadriolobata, which was found in the urinary bladder of Reinhardtius hippoglossoides and Atheresthes evermani. The fish studied here came from the Northern Atlantic and Pacific.

The purpose of this paper is to make a detailed study of parasitic fauna of blue halibut from the North Atlantic or, to be more precise, from two water regions which are distanced from one another, i.e., from the Labrador region and from the Barents Sea, and to include all the systematic groups of parasites. The initial plan was to compare the parasitic fauna of this host from the North Atlantic fishing grounds with the parasitic fauna of blue halibut from Pacific fisheries. This topic could not be fully covered because of the small number of fish obtained from the Pacific (due to fishing limitations imposed by the USA). As 7/
a result, it was decided that this study would instead compare parasitic fauna of blue halibut from the two ecologically different environments of the North Atlantic given above. The adopted framework thus also made it possible to supplement missing data on the parasitic fauna of this host in relation to fish age.

The practical side of this paper consisted of evaluating the degree of infection in blue halibut and, in particular, of determining the occurrence of parasites which are pathogenic for humans and localizing them in the fish. This aspect of the study may be useful in processing this species of fish.

2. MATERIAL AND METHODS OF RESEARCH

The fish studied here came mainly from the North-western Atlantic and the Barents Sea. The exact position of the fishing areas were $53^{o}20'N$, $52^{o}20'W$ in the Labrador fishing grounds and $72^{o}34'N$, $15^{o}00'E$ in the Barents Sea (Fig. 1). Material from the Labrador area was caught on 26 June 1976; material from the Barents Sea was caught on 6 May 1977. Fish for analysis were frozen on the ship to a temperature of less than $-20^{o}C$ and were delivered in this state to the Department of Ichthyopathology and Toxicology of the Academy of Agriculture in Szczecin where parasitological examinations were conducted.

The total number of blue halibut (Reinhardtius hippoglossoides (Walbaum, 1792)) studied was 261, which included 155 individuals from the Labrador fishing grounds and 106 from the Barents Sea. The length of the fish studied (longitudo totalis) was 24.2 - 77.5 cm, while the mass was 75 - 5140 g (Table 1). The age of the blue halibut was determined on the basis of scales taken from the base of the tail above the lateral line (Krzykawski, 1976) and ranged from 3+ to 10+ in the Labrador

region and from 4+ to 13+ in the Barents Sea. Table 1 shows that individuals aged 5+, 6+ and 7+ predominated among the individuals from the Barents Sea and that they constituted 68.9% of the population studied. Fish obtained from the fishing grounds of Labrador in the same age group constituted 43.9% of the population, while the 3+ and 4+ age groups were represented more numerously (52.9%).

Table 1. Comparison of data on examined individuals of blue halibut from the North Atlantic

Age	Number of examined fish		
	Labrador Region	Barents Sea	Total
3+	25	-	25
4+	57	3	60
5+	27	26	53
6+	27	27	54
7+	14	20	34
8+	3	9	12
9+	-	7	7
10+	2	3	5
11+	-	7	7
12+	-	2	2
13+	-	2	2
Total	155	106	261
Length of fish (l.t.) in cm.	24,2-73,3	36,5-77,5	24,2-77,5
Mass in g.	75-4030	350-5140	75-5140

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In addition to the above, studies of parasitic fauna of blue halibut from the North Pacific were also carried out, although they were based on only a small number of individuals. The fish were caught in the spring period of 1981 in a fishing area in the eastern part of the Bering Sea and were shipped to the department in a frozen state. Seven blue halibut were studied from among these specimens. The dimensions of the selected fish (longitudo totalis) ranged from 55.5 to 82.5 cm, while their mass ranged from 1530 to 6200 g. They were 7+ - 14+ years of age.

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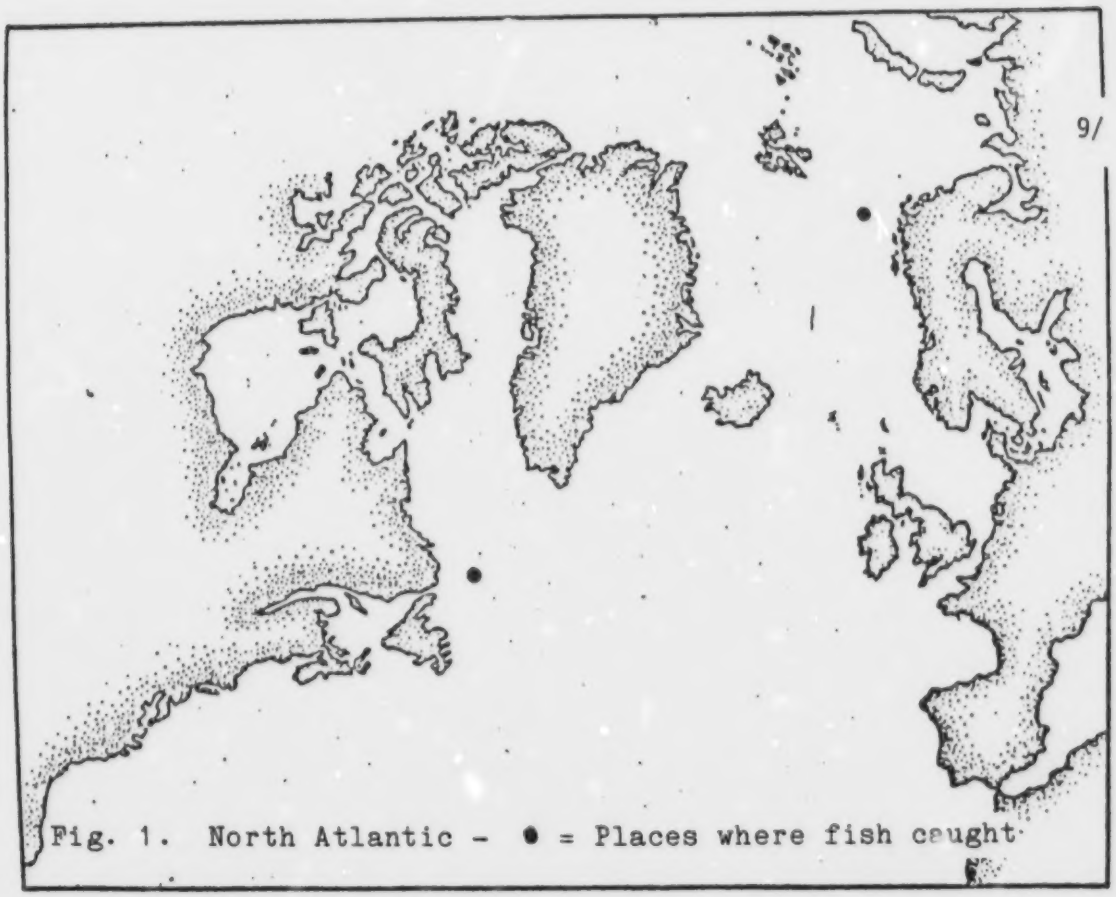

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Fig. 1. North Atlantic - • = Places where fish caught

The fish underwent detailed parasitological examination. The following were studied: skin, fins, eyes, nostrils, gills, oral cavity, body cavity, stomach, intestine, liver, gall bladder, heart, kidney, urinary bladder, spleen, gonads and muscles. Preparations from the vitreous body and lens of the eyes as well as all of the branchial arches were studied under a stereoscopic microscope. A decantation method was used to examine the alimentary canal. The muscles, liver and gonads were comminuted and studied macroscopically. Microscopic studies were also made of suspension from the gall bladder, scrapings from the urinary bladder, nostrils and gills, and selected samples from parenchymatous organs and skeletal muscles.

In cases where higher invasions of protozoa were found, fragments of the attacked organs or their scrapings as well as suspension from the gall bladder were preserved in 5% formalin for further study. Some observations related to protozoa were also carried out on non-preserved material (immediately after thawing). Parasites of the systematic groups Monogenea, Cestoda, Trematoda and Acanthocephala found in this material were slightly flattened for the most part and preserved in 75% ethyl alcohol; afterwards, they were stained in alum or borax carmine, dehydrated in alcohol, and then were enclosed in Canada balsam. Isolated specimens of Nematoda were conserved in a 5% solution of formalin in physiological fluid. Parasites from this group and, to a certain extent, (non-flattened) acanthocephalans were

X-rayed in glycerine and their systematic affiliation was determined without making permanent preparations. A 5% solution of formalin was used to preserve the Crustacea collected.

Results of studies of halibut from the area of Labrador and the Barents Sea (with the exception of Protozoa) were analyzed statistically. The numerical distribution of various species of parasites found in fish in different age groups from both fishing areas was verified using the Fmax test (Sokal, Rohlf, 1981). Since this distribution did not approximate the norm in almost all of the species, non-parametric tests were used for further statistical processing of data. The Kruskal-Wallis and Wilcoxon test (Sokal, Rohlf, 1981) was used for two samples to determine whether there were significant differences with respect to infection between blue halibut in different age groups. All the examined individuals (infected and non-infected) were taken into consideration when carrying out calculations; in the case of some species of parasites, only infected fish were analyzed in addition. Wilcoxon's test was used on both samples to check significant differences between the Labrador and Barents Sea fishing grounds with regard to infection of the host. All of the examined population was taken into consideration when comparing these regions in order to exclude the influence of age on the degree of infection with a given species. The level of significance adopted in all statistical calculations was $\alpha = 0.05$. 11/

3. RESULTS

3.1. Morphological Description of Some Species of Parasites

The morphology of most of the parasites found in the fish did not diverge from descriptions given in original studies or other papers. Nevertheless, some of the species found in the examined blue halibut differed somewhat from available data with respect to morphology and require more detailed descriptions or a certain amount of supplementation and explanation.

3.1.1. Protozoa

Order: Bivalvulida.

Ceratomyxa drepanopsettae Awerinzew, 1908.

Localization in host: Gall bladder.

Only spores of this species were found (Fig. 2, 3). According to my observations, they are slightly curved in the shape of an arc and somewhat asymetric. There are polar capsules close to the front edge of the spores which is more curved than the rear edge. The ends of the spores are slightly narrower, rounded and blunt. The raphe line is straight and relatively easy to observe, and the walls are thin and delicate. Two polar capsules which are almost spherical in shape lie close to one another at the front end of the spore directly by the raphe line and have short contracted orifice canals. The sporoplasm of the embryo does not penetrate into the narrowed ends of the spores. A thin membrane was observed in some spores which separates the polar capsules and the sporoplasm of the embryo (Fig. 2).

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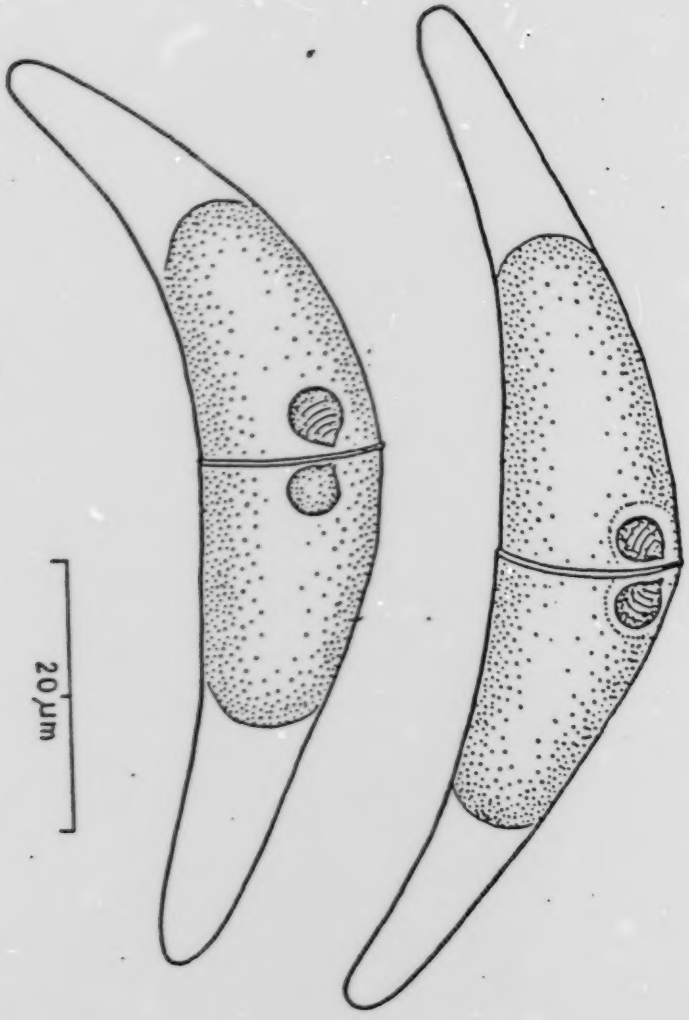

Fig. 2. Spores of Ceratomyxa drepanopsettae (from the Atlantic - Labrador) (orig.)

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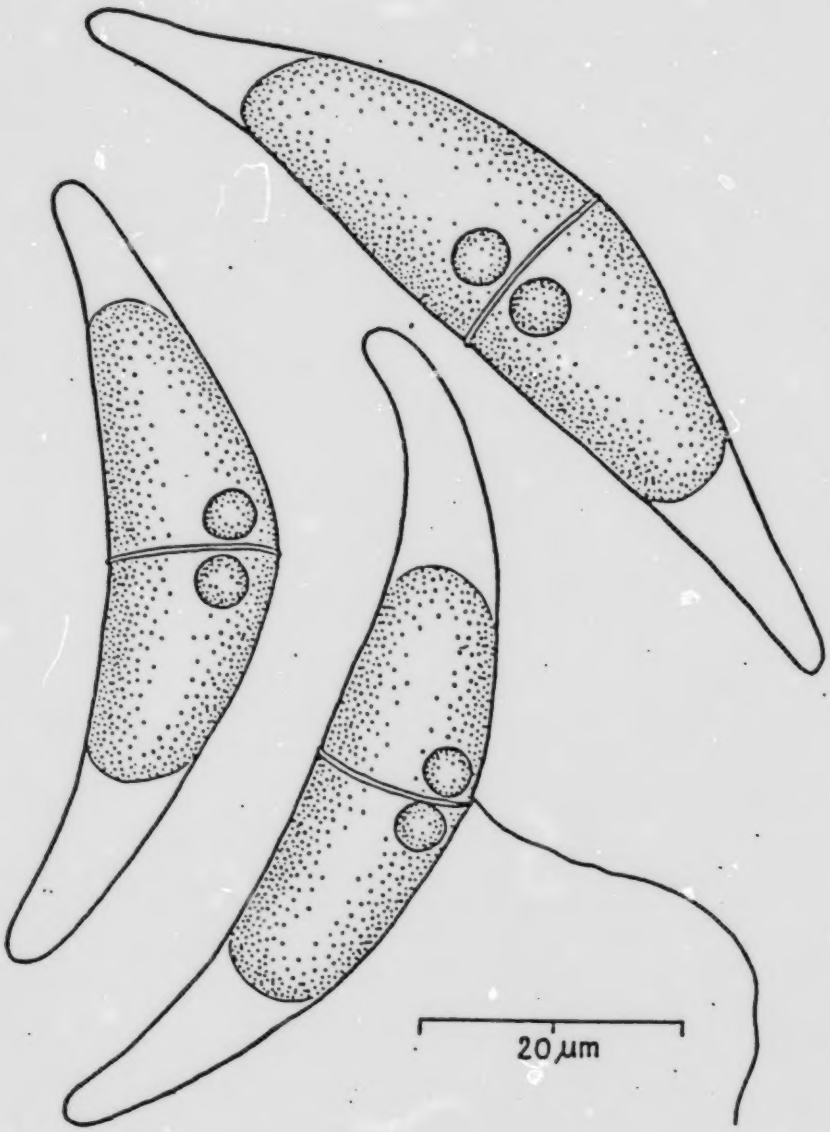

Fig. 3. Spores of Ceratomyxa drepanopsettae (from the Pacific) (orig.)

The spores were measured according to the diagram given by Shulman (1966, 1984). Results (taken from preserved material) are given in micrometers: 14/

	Labrador Region (26 spores measured)	Bering Sea (26 spores measured)
Spore Length	12.4 - 15.0 (13.62 ± 0.80)*	12.0 - 13.2 (12.57 ± 0.51)
Spore Width	56.0 - 79.0 (69.71 ± 5.72)	54.0 - 70.0 (64.60 ± 4.14)
Width of Polar Capsules	3.6 - 4.4 (3.96 ± 0.27)	3.6 - 4.4 (3.79 ± 0.24)

Myxidium incurvatum Thelohan, 1892.

Localization in host: Gall bladder.

My observations showed that spores of this parasite are elongated, quite highly curved in an S-shape, and have sharp ends (Fig. 4). The edges of the spores between the polar capsules are parallel to one another. The polar capsules are pear-shaped with the front poles being distinctly sharp. The raphe line is not well marked; it runs parallel to the lateral edges and then turns towards the tapered ends. The surface of the spores is smooth and there is no striation. The sporoplasm of the embryo is located between the polar capsules.

---

*The arithmetic average of the samples and the standard deviation are given in parentheses. This remark also applies to the measurements of spores of other species given below.

Spore measurements (taken from preserved material) are given in micrometers according to the diagram given by Shulman (1966, 1984):

	Labrador Region (26 spores measured)	Bering Sea (26 spores measured)
Spore Length	12.0 - 16.8 (14.47 ± 1.23)	13.6 - 16.4 (15.07 ± 0.99)
Spore Width	7.2 - 8.8 (8.23 ± 0.41)	7.6 - 8.8 (8.16 ± 0.40)
Spore Thickness	5.6 - 7.6 (6.77 ± 0.55)	7.2 - 8.0 (7.54 ± 0.36)
Length of Polar Capsules	3.6 - 4.8 (4.21 ± 0.35)	4.0 - 4.8 (4.45 ± 0.28)
Width of Polar Capsules	2.4 - 3.2 (2.67 ± 0.27)	2.4 - 3.2 (2.75 ± 0.25)

Ortholinea divergens (Thelohan, 1895).

Localization in host: Gall bladder.

The examined material showed that the shape of the spores of this species is almost spherical on the raphe line plane and flattened with respect to the plane which is perpendicular to the raphe line (Fig. 5). The thickness of the spore is therefore distinctly smaller that its width. There are delicate striae on the whole surface of the spore. Two polar capsules which are spherically pear-shaped are located close to the front edge on the raphe line plane. Their sharp ends are short and contain orifices which are a long distance from each other and almost

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at opposite sides of the spore. Embryo sporoplasm is located primarily under the polar capsules.

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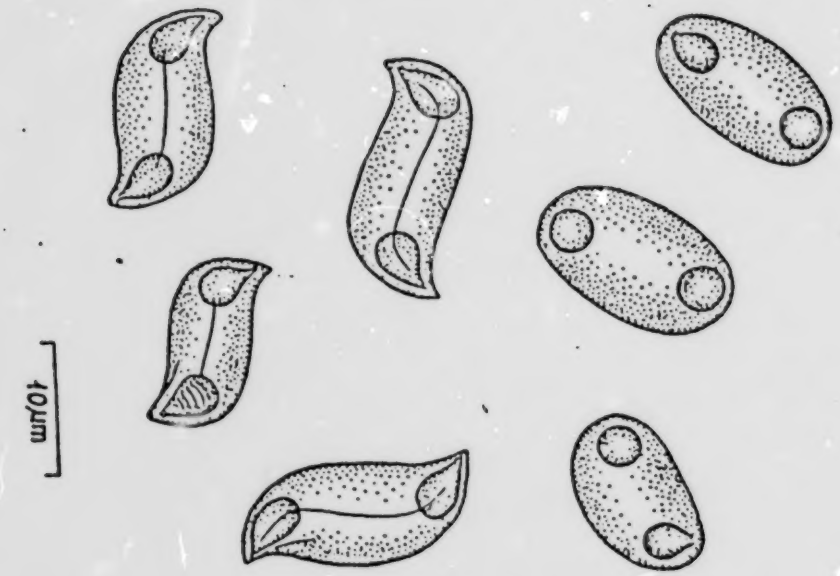

Fig. 4. Spores of Myxidium incurvatum (from the Atlantic - Labrador) (orig.)

The spores were measured according to the diagram given by Shulman (1966). Results from the Barents Sea are given in micrometers:

	(non-preserved material; 10 spores measured)	(preserved material; 25 spores measured)
Spore Length	8.0 - 10.0 (9.17 ± 0.78)	8.0 - 8.8 (8.34 ± 0.36)
Spore Width	8.8 - 10.0 (9.44 ± 0.39)	8.0 - 9.2 (8.37 ± 0.34)
Spore Thickness	4.8 - 5.4 (5.12 ± 0.30)	4.8 - 6.8 (5.90 ± 0.57)
Width of Polar Capsules	--	2.4 - 3.2 (2.62 ± 0.26)
Length of Polar Threads	approx. 20.0	--

The trophic stages of the three species described above were difficult to identify because examinations were carried out on frozen material.

Paramyxoproteus reinhardti Wierzbicka, 1986.

Localization in host: Urinary bladder.

A detailed description of this species and the characteristics of a newly described type of Paramyxoproteus are given in a study by Wierzbicka (1986).

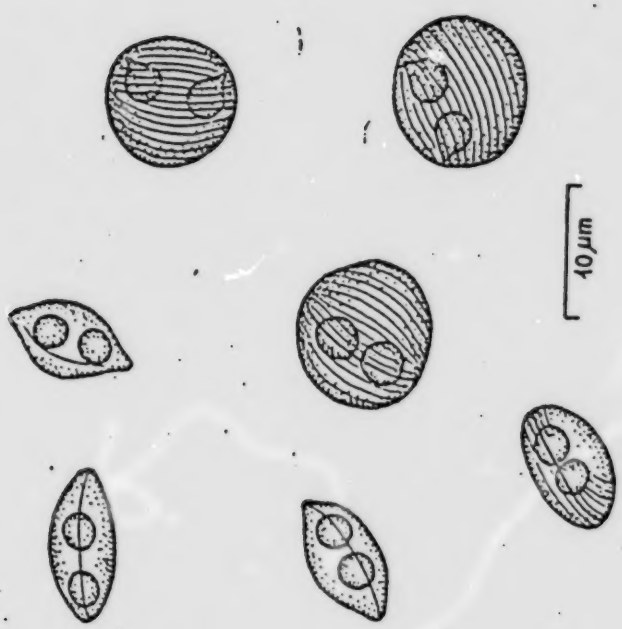

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Fig. 5. Spores of Ortholinea divergens (from the Barents Sea, non-preserved material) (orig.)

3.1.2. Cestoda

Order: Tetraphyllidea.

Scolex pleuronectis Muller, 1788.

Localization in host: Intestine.

The plercercoids of this species found in the examined material have 4 oval, quite distinctly elongated bothridia on their scolex (Fig. 6). There is a transverse septum in their

median part. At the apex of the scolex, there is an additional adhesive organ in the form of a small acetabulum. Individuals with collapsed adhesive organs were often found in the examined material (Fig. 6). The length of the plercercoids was 0.46 - 1.62 mm, while the length ranged from 0.29 to 0.50 mm. The dimensions of the adhesive organs were: acetabulum width = 0.58 - 0.093 mm; length of bothridia = 0.119 - 0.204 mm; width of bothridia = 0.085 - 0.127 mm. These measurements were taken of (slightly flattened) permanent preparations .

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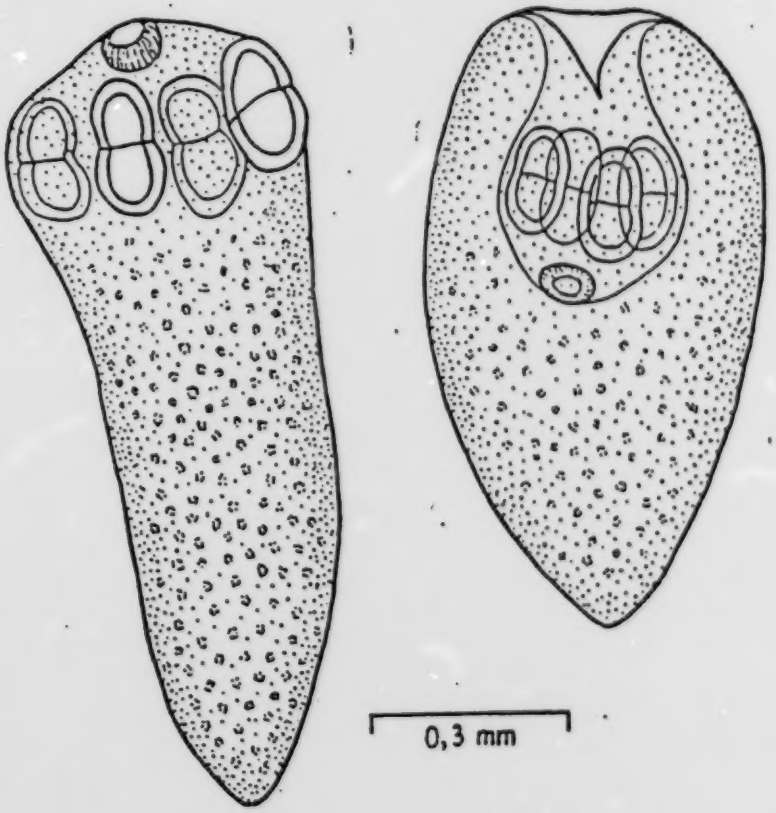

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Fig. 6. Scolex pleuronectis - plerocercoids (orig.)

3.1.3. Crustacea

Order: Copepoda.

Hatschekia sp.

Localization in host: Gills.

Female Morphology

These descriptions use the specific nomenclature introduced by Kabata (1979) which departs from findings on, for example, free-living copepods.

My observations show that the body of this highly elongated parasite has obliterated segmentation (Fig. 7). The dorsal plate of the cephalothorax is somewhat rounded and has a characteristic pattern of oblong swelling (Fig. 8a). Its lateral edges are bent slightly downwards. The segment which contains the second pair of truncal limbs is separated from the cephalothorax and genital thorax by small contractions. The genital thorax is elongated and flattened, and its lateral edges are almost parallel. In adult individuals, it is approx. 6 - 9 times longer than the cephalothorax. The rear lateral tips of the genital thorax are shaped like rounded lobes which most often do not extend beyond the rear edge of the abdomen. The abdomen itself is unisegmental, indistinctly separated from the thorax, and small with well developed uropods (Fig. 7). Small cuticular teeth were observed on the surface of the whole body (with the exception of the dorsal lamina of the cephalothorax).

The length of the female was 6.0 - 11.5 mm and the width was 1.5 - 2.1 mm. Females with attached egg sacs measured from 8.0 to 11.5 mm; the egg sacs were up to 22 mm in length.

The cephalothorax is equipped with 5 pairs of appendages: antennae - first pair; antennae - second pair; masticators*; mandibles* - first pair; and mandibles* - second pair.

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The first pair of antennae are uniramous; their ends are somewhat tapered and composed of 6 slightly separated segments (Fig. 9). Their base segment, which constitutes almost 1/3 of the whole body length, is equipped with two unequal setae on the dorsal side and seven wide setae of various sizes on the front edge. The second segment has six similar setae on the front edge. The third has two unequal setae on the front edge and one smaller seta on the rear edge. There are two setae on the front edge of the fourth segment, which is usually very difficult to distinguish. The fifth segment is equipped with one slender seta on the rear edge. The longest, fairly wide seta (extending beyond the tip of the appendage) is located on the distal edge of the fifth segment along with two smaller setae, the longer one of which grows in the place where the fifth and end segments are joined (Fig. 10a). At the tip of the last segment, there are three wide and quite long setae, five thin and long setae,

*Translator's note: The nomenclature used by the author has been retained in this translation. According to English reference materials, these appendages may also be referred to as antennae (2 pairs), a pair of jaws (mandibles), and two pairs of mouthparts (maxillae).

two short setae (similar to barbs) and one thin and fairly short seta at the very tip between two wide seta. The end portion of the first pair of antennae (fifth and end segments) contains a total of 15 different setae (Fig. 10a).

The second pair of antennae are trisegmental and uniramous. The base segment is short, the second is relatively long and distally tapered, and the third takes the form of a long, curved claw with a sharp end (Fig. 10b). There is a well developed parabasal nodule (not shown in the diagram) at the base of the antenna which has a wide base with two flat lateral protuberances and a central part which is similar to a cone in shape.

The masticators are non-segmental, flat, and equipped with three triangular teeth (Fig. 11a).

The first pair of mandibles are biramous (Fig. 11b). The endopodite is short and rather wide with three appendages: one has a rounded apex, while the second lateral appendage and the central appendage become gradually narrower and have thin tips with sharp ends. The central appendage is considerably longer. The exopodite is slenderer and longer as compared to the endopodite. It has two appendages which gradually become narrower towards the end; the lateral appendage is approx. three times shorter than the internal one.

The second pair of mandibles are uniramous, composed of three segments, and are shaped like an arm with a short base segment (Fig. 11c).

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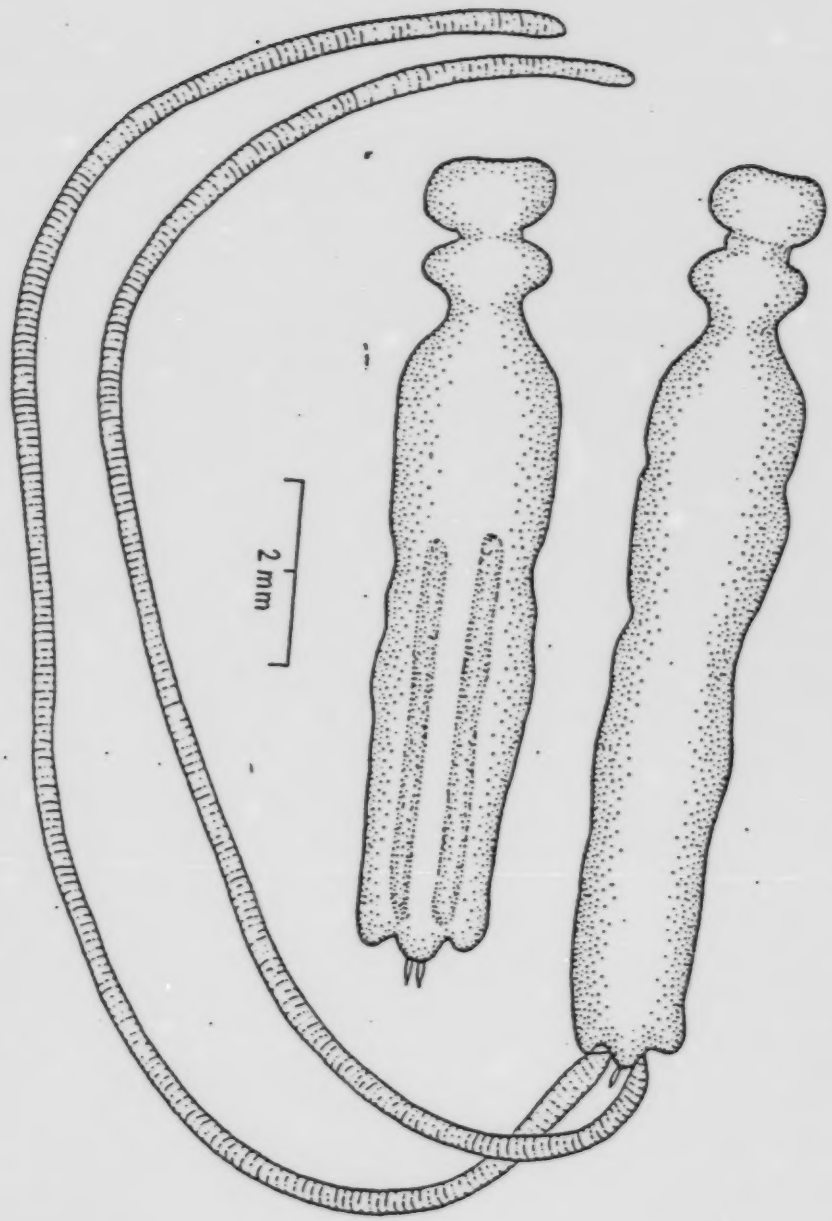

Fig. 7. Hatschekia sp. - females (from the dorsal side) (orig.)

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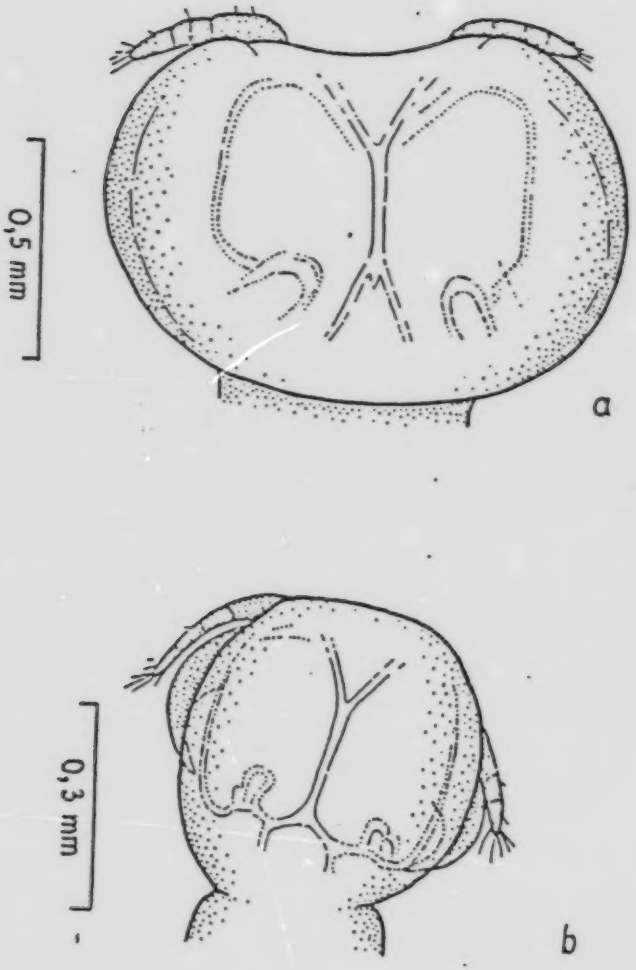

Fig. 8. Cephalothorax of Hatschekia sp.: a - female, b - male (from the dorsal side) (orig.)

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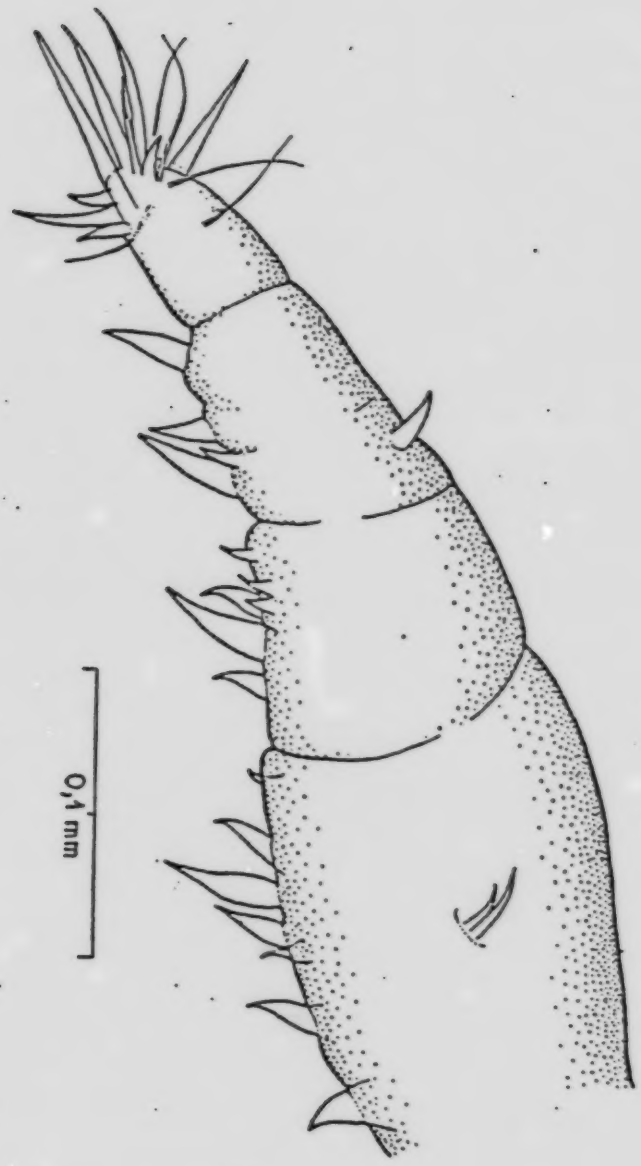

Fig. 9. First pair of antenna of the Hatschekia sp. female (from the dorsal side) (orig.)

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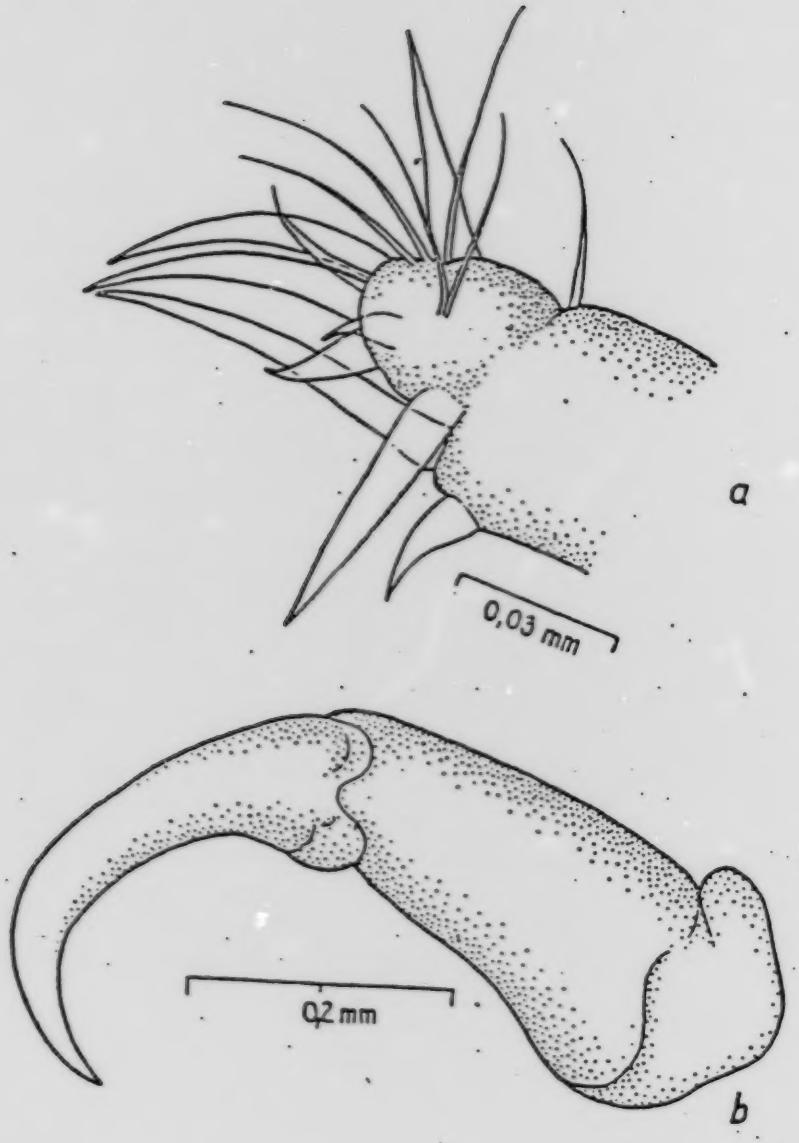

Fig. 10. Hatschekia sp., female: a - end of antenna (first pair) (from the abdominal and lateral side), b - antenna (second pair) (from dorsal side) (orig.)

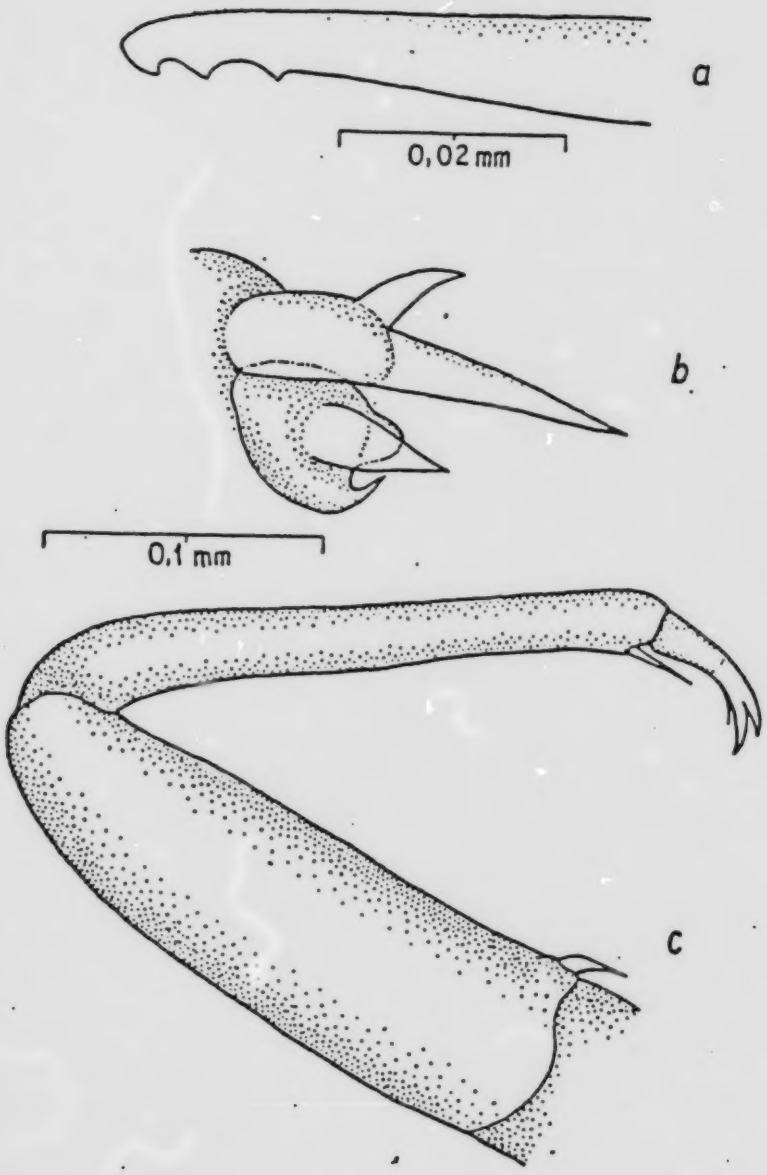

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Fig. 11. Hatschekia sp., female: a - masticator (from lateral side), b - mandible (first pair), c - mandible (second pair) (from abdominal side) (orig.)

The second segment (lacertus) is very elongated and wide with a small seta-like barb on the internal edge by the base. The next (third) segment (brachium) is slender, similarly elongated, and has a short seta on the internal edge by the distal end. There is a relatively small, forked, somewhat curved claw with a delicate seta (which is not always visible) on the internal edge. 26/

The first two pairs of truncal limbs are biramous (Fig. 12). They have flattened bases of sympodia and form large ventral and lateral tumefactions; these are significantly larger in the case of the second pair as compared to the first pair (not marked in the diagram). The sympodium of the first limb is equipped with a rather wide appendage located close to the base of the proximal segment of the endopodite; in addition, the sympodia of the first and second pairs of truncal limbs each have one seta growing at the base of the exopodite (Fig. 12a, b). The exopodite and the endopodite of the first and second pairs of limbs are bisegmental and equipped with setae without hairs. There were 3 longer setae on the apex of the endopodite of the first pair of limbs, whereas 4 similar setae were found on the apex of the exopodite of this limb together with one seta on the proximal segment in the place where it joins the end segment (Fig. 12a). The endopite of the second pair of limbs has 4 setae on the apex (the lateral ones are very short) and one short seta on the proximal segment (Fig. 12b). The exopodite of this pair of limbs is equipped with 4 longer setae and one short seta on

the apex, and one short seta on the proximal segment. There are transverse swellings of cuticle which are curved in a somewhat arched shape; in addition, small clusters of tiny teeth can be seen on the abdominal side of the proximal segments of the exopodites (Fig. 12).

The third pair of truncal limbs are reduced to two small setae (Fig. 13a). These limbs are located just behind the narrowing by the lateral edge of the genital thorax. The fourth pair of limbs is similar to the third pair; in some individuals, complete atrophy of these limbs was observed.

The uropods are cylindrical, slightly tapered toward the tip, and terminated by a wide, seta-like appendage with two short appendages at the sides (Fig. 13b). The tip and the lateral appendages are covered with thin hairs. Moreover, they have one rather long seta on the dorsal side and two (one short, another long) setae on the lateral edge.

Male Morphology

The structure of the male is similar to that of the female; 29/
the male, however, is considerably smaller (Fig. 14). Its body is flattened and quite elongated with segmentation which is almost completely obliterated. The dorsal plate of the cephalothorax is more rounded and transparent than in the female; it also has a characteristic pattern of swellings (Fig. 8b). The cephalothorax constitutes approx. 1/4 of the overall length.

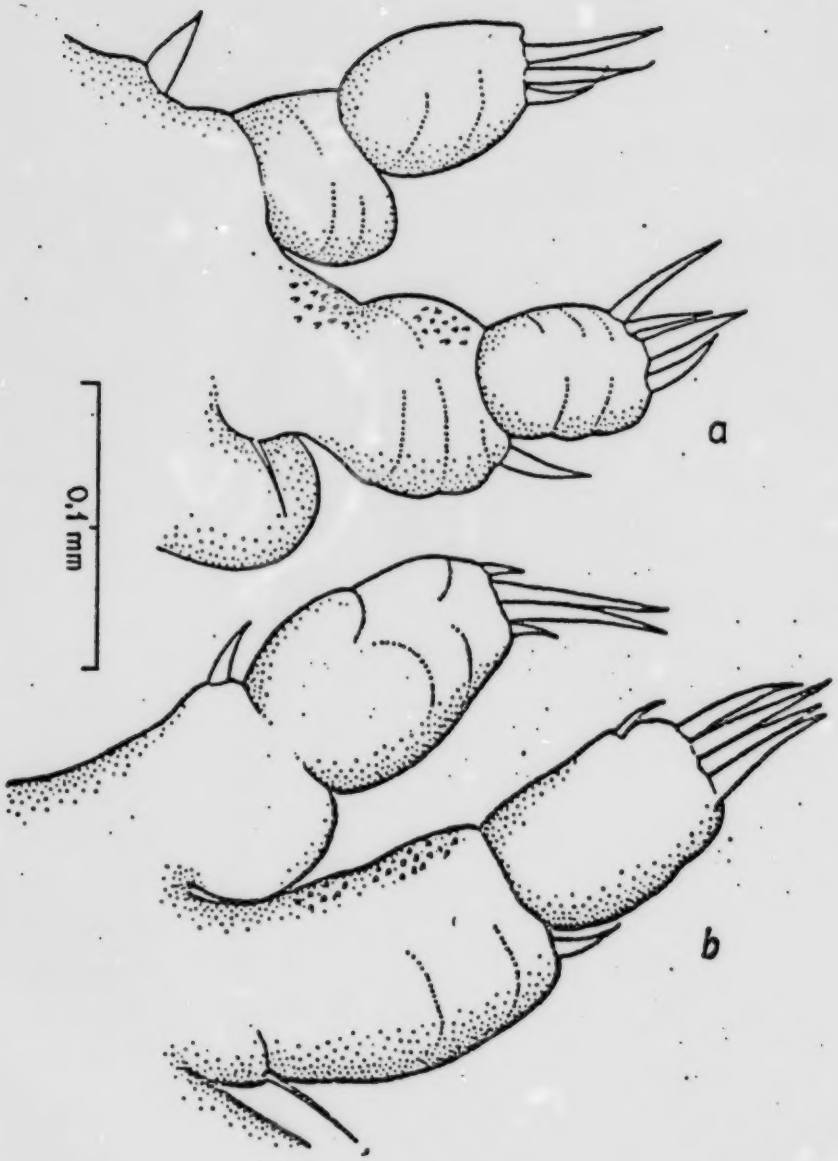

Fig. 12. Limbs of the Hatschekia sp. female: a - first pair; b - second pair (from abdominal side) (orig.)

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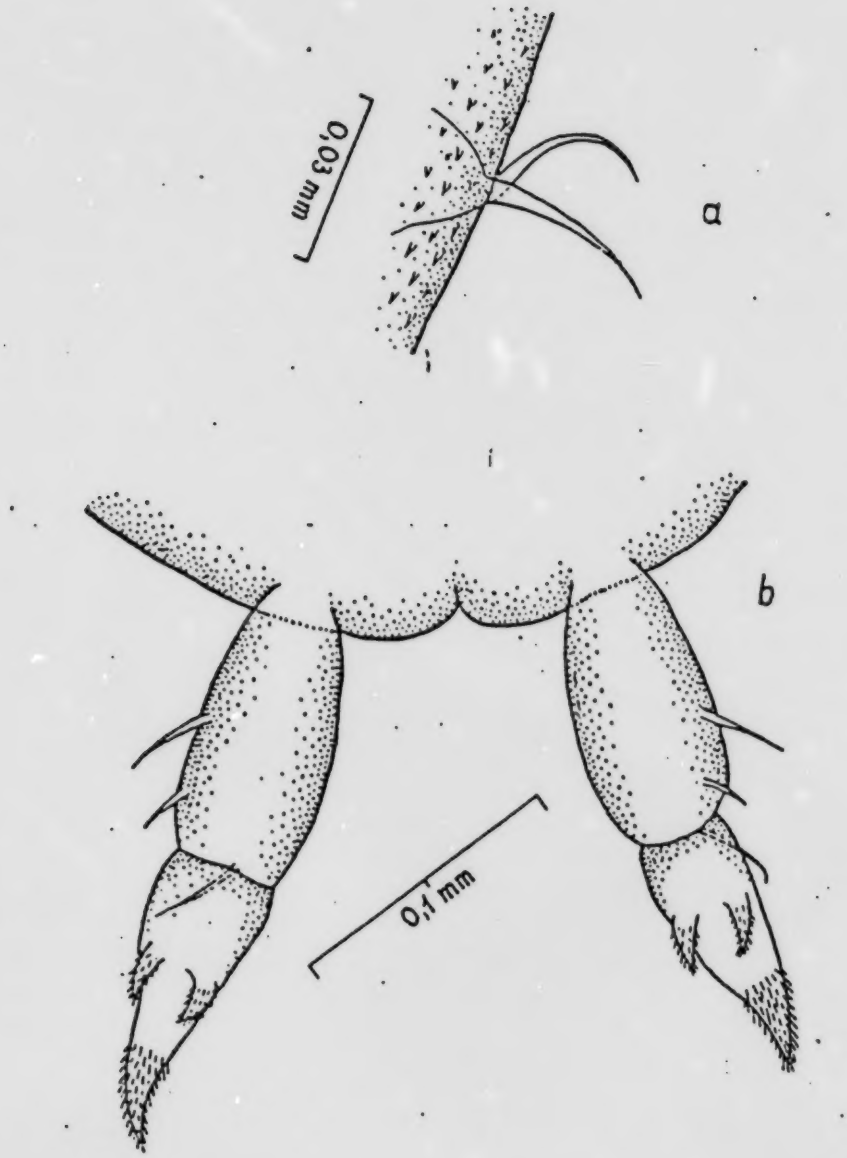

Fig. 13. Hatschekia sp., female: a - limb (third pair), b - uropod (from abdominal side) (orig.)

The segment which contains the second pair of truncal limbs is separated from the cephalothorax and the genital thorax by small narrowings. The genital thorax is approx. two times longer than the cephalothorax. The end part of the genital thorax becomes somewhat narrower and turns into a small, unisegmental and rather distinctly marked abdomen with well developed uropods (Fig. 14). Numerous tiny cuticular teeth were observed on the surface of the genital thorax.

The overall length of the males found in this study was 1.8 - 1.9 mm; their width was 0.40 - 0.45 mm.

As in the female, there are 5 pairs of appendages on the cephalothorax: a first pair of antennae, a second pair of antennae, masticators, a first pair of mandibles and a second pair of mandibles.

The morphology of the first and second pairs of antennae is almost exactly the same as that of the female since the differences observed are insignificant. The first pair of antennae in the male have three rather large setae on the front edge of the fourth segment (Fig. 15), while there are only two setae on the same segment in the female. The second pair of antennae in the male are equipped with a small barb located by the base of the end segment (Fig. 16a), while there is no barb located there in the female. The masticators (Fig. 18a), first pair of mandibles (Fig. 16b) and second pair of mandibles (Fig. 16c) of the male and female are identical with the only difference being with

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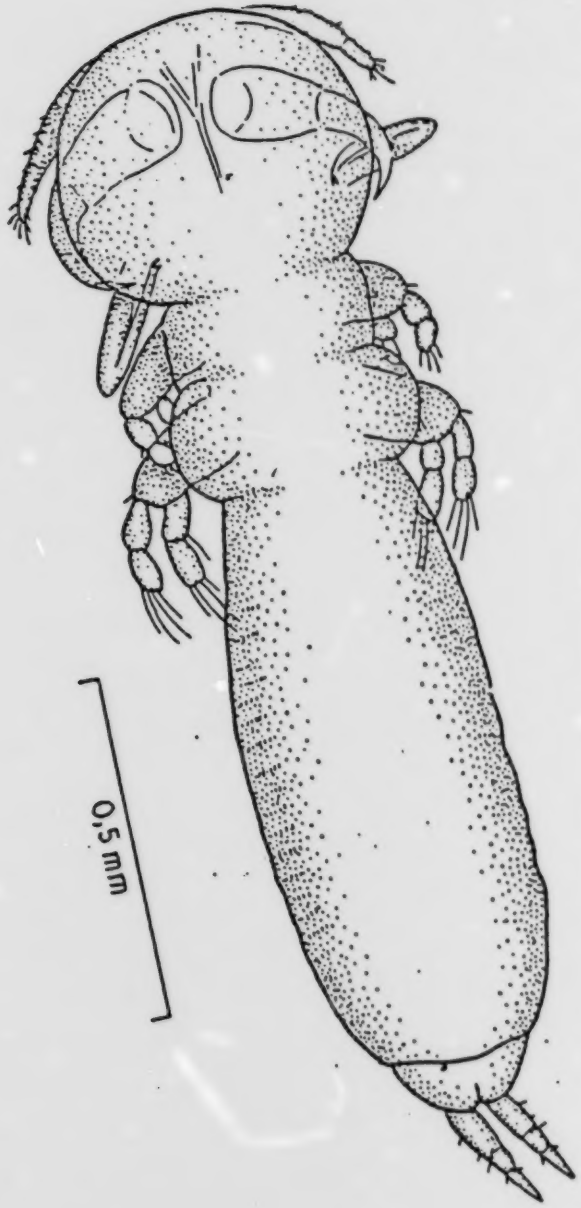

Fig. 14. Hatschekia sp. - male (from dorsal side) (orig.)

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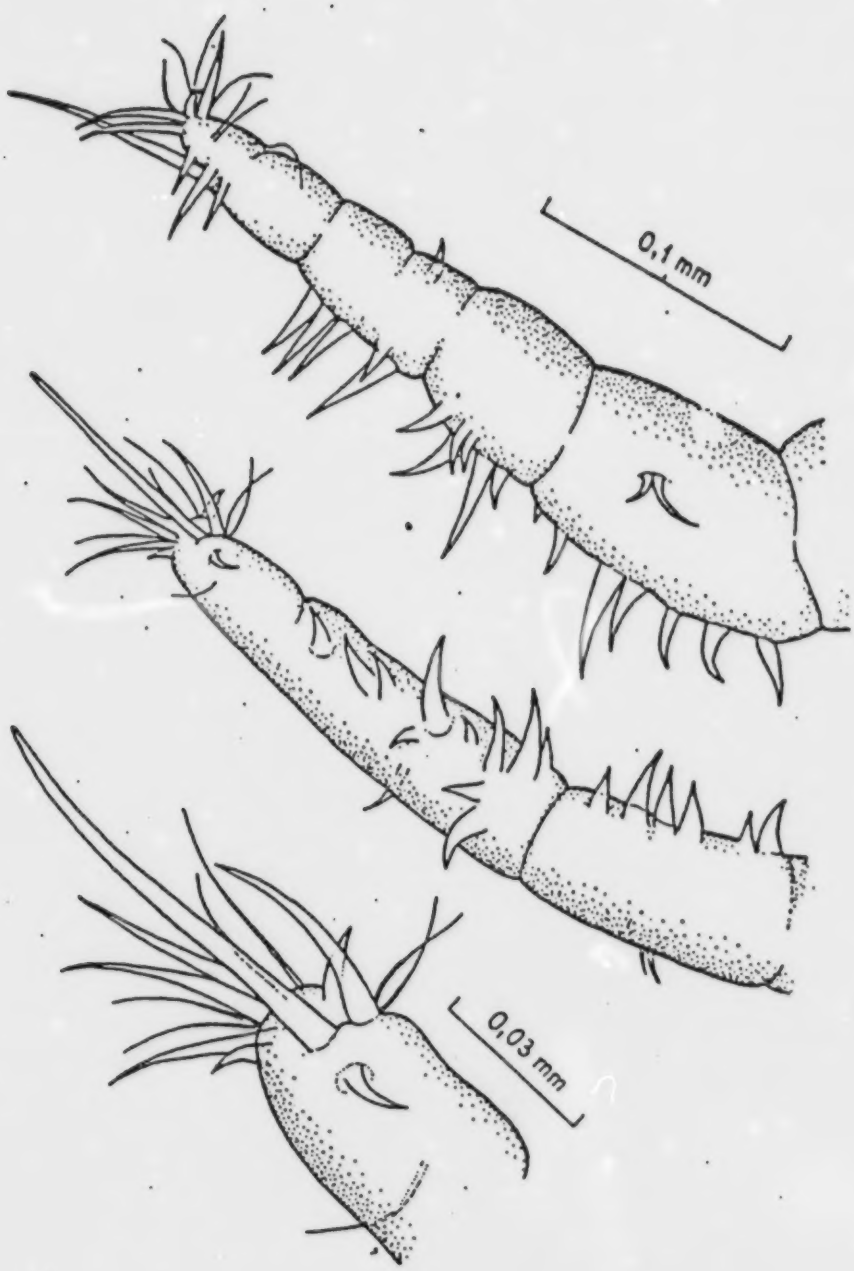

Fig. 15. First pair of antennae of Hatschekia sp. male (various arrangements) (orig.)

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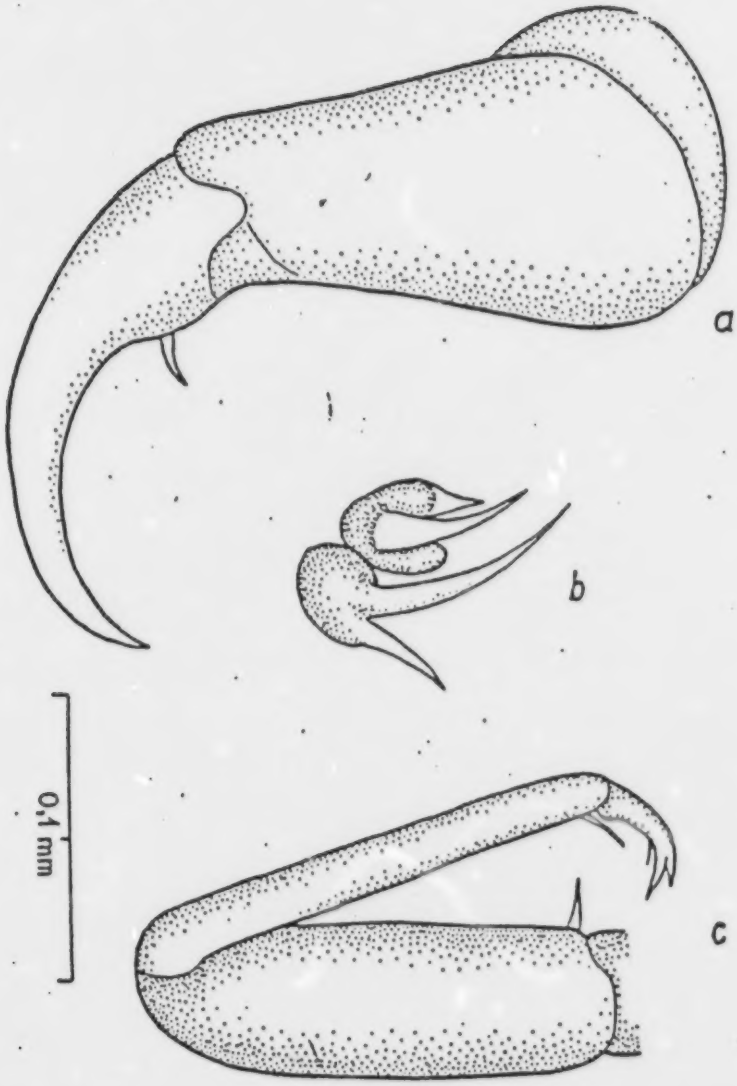

Fig. 16. Hatschekia sp., male: a - antenna (second pair), b - mandible (first pair), c - mandible (second pair) (from abdominal side) (orig.)

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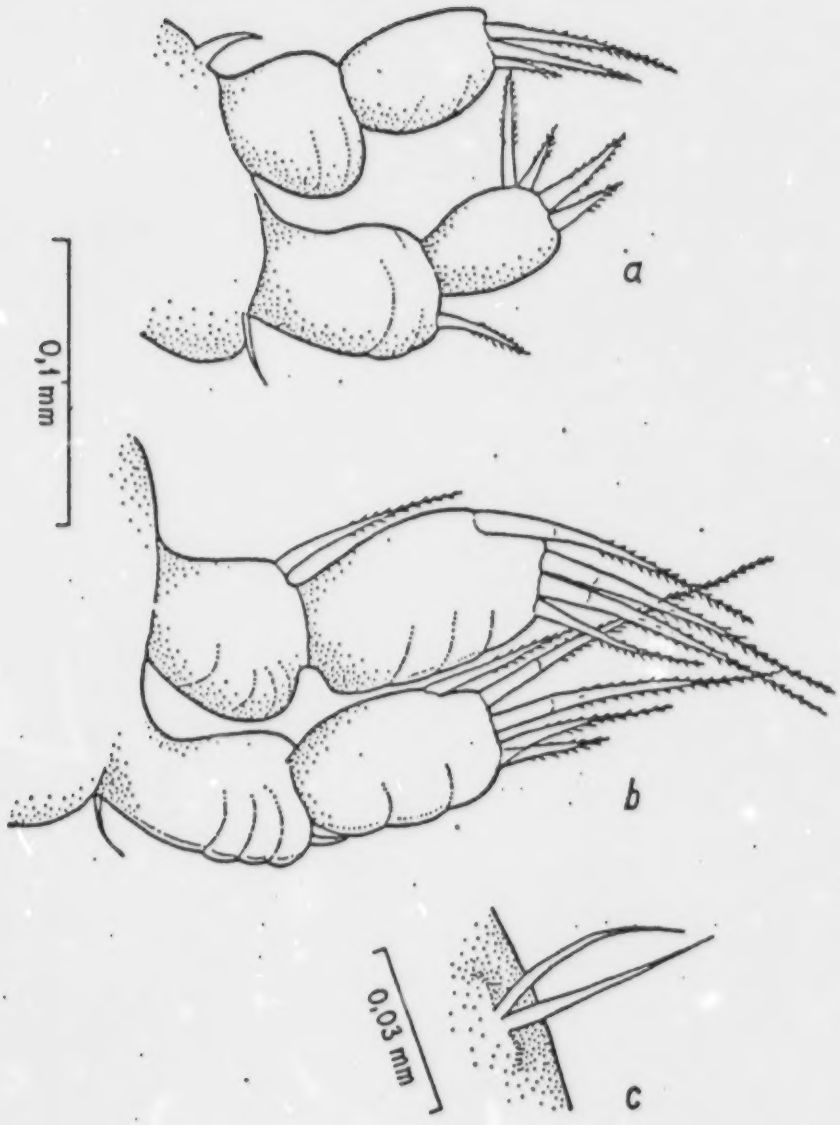

Fig. 17. Limbs of Hatschekia sp. male: a - first pair, b - second pair, c - third pair (from abdominal side) (orig.)

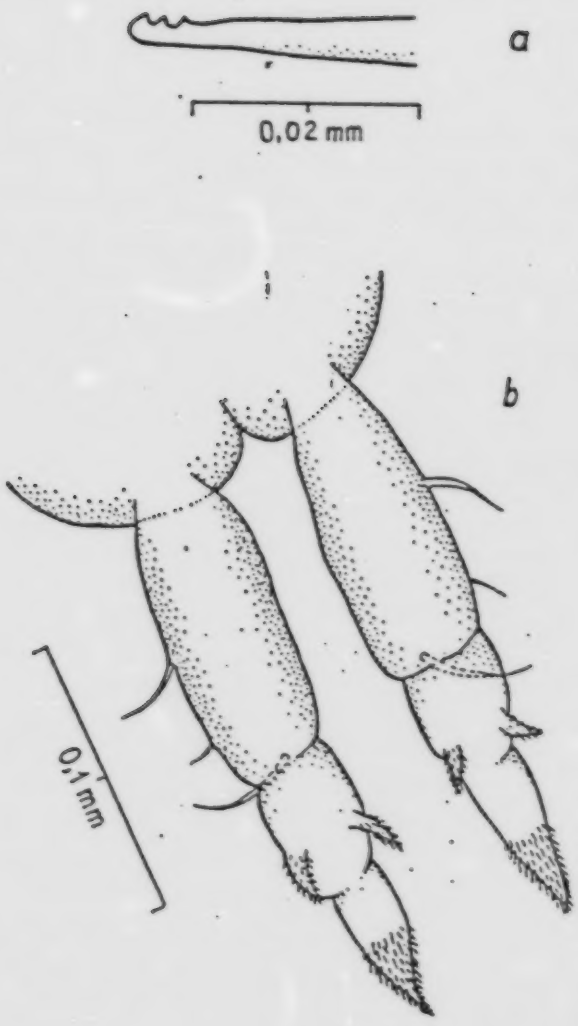

Fig. 18. Hatschekia sp., male: a - masticator (from lateral side), b - uropod (from abdominal side) (orig.)

respect to dimensions (they are somewhat smaller in the male).

The first and second pairs of truncal limbs are very similar to the limbs of the female. The only difference is that there are thin hairs on the setae of the exopodite and the endopodite of both limbs in the male (Fig. 17a, b). Moreover, the setae of the exopodite and the endopodite of the second pair of limbs are significantly longer than in the female. The third and fourth pairs of truncal limbs are reduced to two small setae as in the female (Fig. 17c). The fourth pair can also disappear completely or only one seta can be present. The uropods of the male (Fig. 18b) do not differ morphologically from the same appendages in the female.

3.2. Parasitic Fauna of Blue Halibut from the Labrador Region 35/

Examinations of blue halibut from the Labrador fishing grounds yielded 19 species of parasites belonging to: Protozoa (4 species), Monogenea (1), Cestoda (2), Trematoda (7), Nematoda (2), Acanthocephala (2) and Crustacea (1 species). The incidence and degree of infection with individual parasites were very different (Tab. 2).

The dominant species of protozoa was Ceratomyxa drepanopsettae, found in the gall bladder of all dissected individuals (Tab. 2). The degree of infection with this parasite was also high; the percentage of fish with very numerous and massively occurring spores was 20.1%, while the percentage of fish with

numerous spores was 34.2%. It was also found that both Paramyxoproteus reinhardti, found in the urinary bladder, and Myxidium incurvatum, parasitizing in the gall bladder, were common parasitic protozoa in the fish population studied here (Tab. 2). A fourth species - Ortholinea divergens, occurring in the urinary bladder - was also one of the rather frequent parasites of blue halibut in this region (41.9% of the fish were infected). As in the case of incidence of infection, the degree of infection with the above protozoa was relatively high (Tab. 2). The percentage of fish infected with very numerous or massively occurring spores was 19.5% in the case of P. reinhardti; 18.5% in the case of O. divergens; and approx. 5% in the case of M. incurvatum. These protozoa were found in the remaining infected blue halibut and ranged in number from individual occurrences to numerous occurrences of spores.

Monogenea were represented by one species assigned to the genus Entobdella Blainville in Lamarck, 1818. This is a parasite which is found sporadically on gills of blue halibut; there was only one individual found in the examined samples (Tab. 2). The rather imprecise arrangement of hooks on the adhesive disc of this individual made it impossible to determine what species it fell into.

Two species of the Cestoda group were found (Tab. 2). One of them - Scolex pleuronectis - was among the common parasites of blue halibut in the Labrador region (76.8% infected). Larvae of

this tapeworm were found in the intestine of dissected fish. The second species - Grillotia erinaceus - was a very rare parasite of this host; only one larva encysted in a stomach wall was found.

Among the flatworms, Trematoda was the group present in the greatest numbers. Seven species of parasites from this class were isolated in the collected material. These were all adult forms living in the alimentary canal. The most dominant were Stenacron vetustum, parasitizing in the intestine, and Derogenes varicus, found in the stomach (Tab. 2). In addition, the intestinal trematode Lecithaster gibbosus was noted quite often (35.5% infected). The intestinal trematodes Steganoderma formosum and Fellodistomum furcigerum were found less often in the examined material (Tab. 2). The trematodes Hemiurus levinseni and Cenarchopsis mülleri (Tab. 2), which live in the stomach, occurred least frequently. H. levinseni was found in two fish, while G. mülleri was only found in one. The nomenclature of the above parasites was adopted in accordance with Yamaguti (1971).

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Two species of nematodes were found in the examined material. Larvae of Thynnascaris adunca belonged to the most common parasites of blue halibut in this region (Tab. 2). They occurred in an encysted form on different organs in the body cavity. The greatest number of nematodes was observed on intenstine walls and between the pyloric processes, on the stomach and in the liver (Tab. 3). A second species - Anisakis simplex - was another

parasite which was rather frequently found in dissected fish (37.4% infected). Encysted larvae of this species established themselves mainly in the body cavity on the same organs as the larvae of Th. adunca. Their distribution was, however, somewhat different (Tab. 3); the greatest number of parasites was found in the liver and on the stomach, while one larva was also found in the skeletal muscles on the dorsal side by the head. The larval forms of both species were in the III stage of development.

Two species of the group Acanthocephala were also found. The number of blue halibut infected with the acanthocephalon Echinorhynchus gadi, which was found in the intenstine of dissected fish, was relatively low (7.7% infected). Corysnosoma strumosum was one of the parasites which was sporadically noted in this host (Tab. 2); only one encysted larva was found in the body cavity.

The crustaceans Neobrachiella rostrata can be included among the parasites which were found rather frequently in the examined fish (23.2% infected). Females of this species were found along the interbranchial septa (52.5% of the ascertained individuals), on branchial arches and lamellae (19%), on the skin (19%) and on the internal side of the branchial integument attached to the pseudobranches (9.5%).

Tab. 2. Infection of blue halibut from different regions

Species of parasite		Labrador region n = 155	Barents Sea n = 106	Bering Sea n = 7
P r o t o z o a - Myxosporidia				
Ceratomyxa drepanopsettae Averintsev, 1968	inc.	100.0	100.0	85,7
	deg.	sing.-massive[x]	sing.-massive	sing.-numerous
Kyrtidium incurvatum Thélohan, 1892	inc.	66,7	25,5	42,9
	deg.	sing.-v.numer.	sing.-numerous	single
Orthelinea divergens /Thélohan, 1895/	inc.	41,9	1,9	0
	deg.	sing.-massive	sing.-numerous	
Paramyxoproteus reinhardti Wierzbicka, 1986	inc.	79.35	92.45	/1/[xx]
	deg.	sing.-massive	sing.-massive	few
N e m a t o d a				
Ascarophis sp.	inc.	0,6		
	deg.	1	0	0
	aver.	1		
C e s t o d a				
Grillotia erinaceus /van Beneden, 1858/, pl.	inc.	0,6		/1/
	deg.	1	0	1
	aver.	1		1
Nybelinia surmenicola Okada in Dollfus, 1929, pl.	inc.		1,9	100,0
	deg.	0	1	6-43
	aver.		1	27,43
Scolex pleuronectis Müller, 1788, pl.	inc.	76,8	31,1	/1/
	deg.	1-57	1-520	4
	aver.	8,55	66,18	4
T r e m a t o d a				
Aporocotyle simplex Odhner, 1900	inc.			/1/
	deg.	0	0	12
	aver.			12
Fellodistomum furcigerum /Olsson, 1867/ Yamaguti, 1954	inc.	9,0	20,75	/1/
	deg.	1-69	1-73	2
	aver.	7,21	14,14	2
Stemacron vetustum Stafford, 1904	inc.	78,1	5,7	
	deg.	1-30	1-7	0
	aver.	4,02	2,83	
Steganoderma formosum Stafford, 1904	inc.	12,3		42,9
	deg.	1-8	0	1
	aver.	2,84		1
Stephanostomum baccatum /Nicoll, 1907/ Manter, 1934, met.	inc.			71,4
	deg.	0	0	1-17
	aver.			5,20
Hemiurus appendiculatus /Rudolphi, 1802/ Looss, 1899	inc.			/1/
	deg.	0	0	3
	aver.			3
Hemiurus levinseni Odhner, 1905	inc.	1,3	7,55	28,6
	deg.	1-25	1-16	1-11
	aver.	13,00	4,62	6,00
Brachyphallus crenatus /Rudolphi, 1802/ Odhner, 1905	inc.			/1/
	deg.	0	0	2
	aver.			2
Derogenes varicus /Müller, 1784/ Looss, 1901	inc.	52,3	74,5	42,9
	deg.	1-23	1-195	1-2
	aver.	2,34	19,87	1,33

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Tab. cont'd on next page

Tab. 2. (cont'd)

Species of parasite		Labrador region	Barents Sea	Bering Sea
Genarchopsis milleri /Levinsen, 1881/ Yamaguti, 1954	Inc.	0,6		
	deg.	1	0	0
	aver.	1		
Lecithaster gibbosus /Rudolphi, 1802/ Lühe, 1901	Inc.	35,5	3,8	
	deg.	1-7	1	0
	aver.	1,56	1	
N e m a t o d a				
Anisakis simplex /Rudolphi, 1809/ Dujardin, 1845, larva	Inc.	37,4	95,5	100,0
	deg.	1-6	1-4168	13-6162
	aver.	1,83	205,90	917,00
Phocanema decipiens /Krabbe, 1878/ Myers, 1959, larva	Inc.		50,9	100,0
	deg.	0	1-18	1-13
	aver.		4,39	6,29
Thynnascaris aduncа /Rudolphi, 1802/, larva III st.	Inc.	91,0	98,1	85,7
	deg.	1-42	1-392	1-289
	aver.	4,14	21,63	50,17
Thynnascaris aduncа /Rudolphi, 1802/, larva IV st. et ad.	Inc.		1,9	100,0
	deg.	0	3-3	1-77
	aver.		2,50	23,00
A c a n t h o c e p h a l a				
Echinorhynchus gadi Zoega in Müller, 1776	Inc.	7,7	1,9	85,7
	deg.	1-48	1-3	1-8
	aver.	1,08	2,00	3,17
Corynosoma strumosum /Rudolphi, 1802/, larva	Inc.	0,6	81,1	/1/
	deg.	1	1-62	1
	aver.	1	5,60	1
Corynosoma semerme /Forssell, 1904/, larva	Inc.		13,1	
	deg.	0	1-2	0
	aver.		1,37	
C r u s t a c e a				
Hatschekia sp.	Inc.			57,1
	deg.	0	0	2-38
	aver.			11,75
Neobrachiella rostrata /Krøyer, 1837/	Inc.	23,2	34,9	
	deg.	1-4	1-15	0
	aver.	1,17	2,32	
Acanthochondria sp.	Inc.			/1/
	deg.	0	0	2
	aver.			2

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n - number of examined fish

Inc. - incidence of infection (% of infected fish)

deg. - degree of infection (number of parasites in one host individual

aver. - average degree of infection (number of parasites per one infected individual in the population)

x - in the case of protozoa: sing. - single spores (in suspension, scraping) under a covering glass; few - up to 10 spores in 30 fields of vision with a magnification of 400x; numerous - approx. 50 spores in 30 fields of vision; very numerous - 5-10 spores in a field of vision; massive - over 10 spores in a field of vision

xx - the number of infected fish in parentheses is given without calculating the percentage

Tab. 3. Occurrence of Nematoda and Acanthocephala larvae in blue halibut

Species of parasite	Region	Total no. of parasites	Percentage of occurrence in individual organs[x]					
			stomach[xx]	intestine and pyloric processes[xx]	liver	gonads	other organs[xxx]	muscles
Anisakis simplex /III st./	Labrador	106	28,3	10,4	45,3	0,9	14,2	0,9
	Barents Sea	20876	75,9	6,0	8,8	1,3	1,1	6,9
	Bering Sea	6419	83,4	1,4	4,3	0,2	1,2	9,5
Phocanema decipiens /III st./	Barents Sea	248	11,3	12,1	68,1	0	8,1	0,4
	Bering Sea	44	0	2,3	11,4	0	0	86,3
Thynnascaris aduncа /III st./	Labrador	584	26,5	39,6	21,7	0	12,2	0
	Barents Sea	2250	21,3	49,8	24,6	0,3	3,7	0,3
	Bering Sea	301	72,4	13,6	11,6	0	1,0	1,4
Corynosoma strumosum	Labrador	1	0	0	0	0	+	0
	Barents Sea	482	18,7	57,9	17,6	1,5	3,9	0,4
	Bering Sea	1	0	+	0	0	0	0
Corynosoma semerme	Barents Sea	22	22,7	45,5	27,3	0	4,5	0

x - total number of parasites of a given taxon assumed to be 100%

xx - in the walls and on the exterior of these organs

xxx - heart, kidney, kidney peritoneum, gall bladder, urinary bladder, spleen or loosely arranged in the body cavity

3.3. Parasitic Fauna of Blue Halibut from the Barents Sea

Examination of blue halibut from the Barents Sea showed the presence of 18 species of parasites belonging to: Protozoa (4 species), Cestoda (2), Trematoda (5), Nematoda (3), Acanthocephala (3) and Crustacea (1 species). Infection with these parasites was highly differentiated. Some of them were noted with great frequency and the degree of infection was also high. 40/

The protozoa most often noted were Ceratomyxa drepanopsattae, occurring in the gall bladder of all the examined fish, and Paramyxoproteus reinhardti, parasitizing in the urinary bladder (Tab. 2). The percentage of infected fish with very numerous and massive spores was 6.6% in the case of C. drepanopsattae, and 21.4% in the case of P. reinhardti. Less intensive infection involving numerous spores was found in 16% of the blue halibut studied in the case of C. drepanopsettae, and 14.5% in the case of P. reinhardti.

The nematodes Anisakis simplex and Thynnascaris adunca were also among the very frequent parasites of blue halibut in this region (Tab. 2). High incidence and degree of infection were characteristic for these species. The maximum number of larvae of A. simplex reached over four thousand in one fish; in the case of Th. adunca, a total of 392 larvae was reached. These were encysted nematodes in the third stage of development. The A. simplex larvae occurred mainly in different organs of the body cavity; the greatest number of nematodes was observed in

the stomach walls (Tab. 3). In addition, they were quite frequently found in the muscles. As many as 1996 larvae were isolated from the muscles of the examined samples; this constituted 6.9% of the total number of individuals found. The nematodes were located principally in the abdominal integument lamellae on the side of the fish turned toward the base (blind side), were less numerous on the opposite side of the body (ocular side), and even less numerous in the muscles of the dorsal part of the thorax. Larvae of Th. adunca were present almost exclusively in the body cavity and were concentrated mainly on the intestine and the pyloric processes, in the liver, and on the stomach (Tab. 3). Individual larvae of this species were also found in the muscles of 8 fish on the abdominal side. In addition to larval forms in the third stage of development, one larva in the fourth stage of development was found in the stomach of a halibut and single adult individuals of Th. adunca were found in two fish (Tab. 2).

The acanthocephalons Corynosoma strumosum and trematodes Derogenes varicus were also common parasites of the examined population (Tab. 2). Encysted immature forms of the acanthocephalon C. strumosum were found on different organs of the body cavity; the decidedly greatest number of these larvae were found in the intestine and pyloric processes (Tab. 3). In one case, two larvae were also found in abdominal integument muscles. Adult forms of the trematode D. varicus were noted primarily in

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the stomach and to a significantly lesser extent in the intestine and in the branchial cavity, which is where they probably went following the death of the fish.

The nematodes Phocanema decipiens were also frequent parasites of blue halibut in the Barents Sea; the incidence of infection in this case was 50.9% (Tab. 2). These were encysted larvae in the third stage of development. They were found most often in the liver and, to a lesser extent, attached to the walls of the alimentary canal or other organs in the body cavity (Tab. 3). Only one larva was found in the examined specimens; it was found in muscles close to the abdominal fins.

The next four species - Myxidium incurvatum, Scolex pleuronctis, Fellodistomum furcigerum and Neobrachiella rostrata - were found slightly less often in the examined material. The incidence of infection with these parasites reached 20.75 - 34.9% (Tab. 2). The protozoa M. incurvatum occurred in the gall bladder, while larvae of the tapeworm S. pleuronectis were found in the intestine. The main characteristic of the latter species was its high degree of infection; the maximum number of tapeworms reached up to 520 specimens in a single fish. The trematode F. furcigerum was also an intestinal parasite. The degree of infection with this species was significantly lower, however (Tab. 2). The crustacean N. rostrata was found most often on branchial arches and lamellae (62.8% of the females collected). In addition, they were also observed attached to

pseudobranches (18.6%) and interbranchial septa (18.6%).

The acanthocephalon Corynosoma semerme was a relatively rare parasite of this host (Tab. 2) and occurred in a larval form on various organs in the body cavity (Tab. 3). Even rarer were the trematodes Stenacron vetustum, living in the intestine, and Hemiurus levinseni, found in the stomach (5.7% and 7.55% (respectively) of the infected fish) (Tab. 2).

The remaining species - Ortholinea divergens, Nybelinia surmenicola, Lecithaster gibbosus and Echinorhynchus gadi - were among the very rare parasites in the examined fish population. The intestinal trematode L. gibbosus was found in four fish, while the remaining species were only found in two (Tab. 2). The protozoa O. divergens were located in the urinary bladder, encysted plerocercoids of the tapeworm N. surmenicola in the stomach walls, and adult speciments of the acanthocephalon E. gadi in the intestine.

3.4. Parasitic Fauna of Fish in Various Age Groups

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Data on infection with parasites of the group Metazoa (degree and average degree of population infection) with respect to individuals of blue halibut in various age groups are given in Table 4 (Labrador region) and Table 5 (Barents Sea). The averages given in the tables were calculated for all species of Metazoa, while it was only possible to formulate study results for Protozoa in terms of incidence and degree of infection (Tab. 6).

The results given in Tables 4 and 5 show that certain tendencies towards an increase in the number of parasites together with an increase in the age of the host occurred only in the case of individual species. This interdependence was most clearly observed with regard to intensification of infection caused by the nematode Anisakis simplex. In the Barents Sea, the average degree of population infection with this species was 8.67 individuals in the 4+ group of fish and gradually grew to as many as over 1,000 larvae in fish whose age was determined to be from 9+ to 11+ (Tab. 5). Infection data were similar in fish from the Labrador region, the only difference being that average values were significantly lower for the various age groups studied (from 0.16 larva in the three year age group to 3.50 individuals in the 10+ age group) (Tab. 4).

A small gradual increase in the average degree of population infection related to an increase in fish age was observed in the case of the trematode Derogenes varicus in fish from the Labrador fishery (Tab. 4), which was similar to the nematode species described above. Infection with this trematode parasite took a completely different form in the Barents Sea as the average degree of population infection in older fish groups was generally lower (Tab. 5). Coming back to the Labrador fishery, it should be added that infection with the trematode Stenacron vetustum was also higher in fish in the 6+, 7+ and 8+ age group in comparison with younger (3+ to 5+) age groups (Tab. 4). This parasite was

not found at all in older individuals of blue halibut from the Barents Sea (Tab. 5). The number of fish caught in the Barents Sea fishing grounds with the tapeworm Scolex pleuronectis was generally higher in older groups (Tab. 5), whereas no tendency for invasion with this species to intensify in fish from the Labrador region was observed (Tab. 4).

The dependence described here was even less defined in the case of the remaining parasites of the group Metazoa or it did not occur at a[illegible] (Tab. 4 and 5).

Statistical analysis of data showed that, with the exception of Anisakis simplex, all the other differences in the degree of infection of fish belonging to various age groups were insignificant. Results of statistical analysis in the case of A. simplex were the following: the number of larvae of this nematode in fish from the Barents Sea was significantly higher in the 8+ age group as compared to the 7+ age group, and in the 9+ age group as compared to the 8+ age group. This statistical dependence was not found in fish from the Labrador fishery when the whole population (infected and non-infected fish) were treated globally. The reason for this was the relatively low degree of infection with this parasite. On the other hand, significant differences in intensification of infection with A. simplex were also found with regard to this area as well when only infected fish were taken into consideration. Statistically significant differences occurred between 3+ and 4+ age groups, 4+ and 5+ age groups, and

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5+ and 6+ age groups.

The data on parasites of the group Protozoa contained in Tab. 6 indicate that there is absolutely no interdependence between infection and age in blue halibut. The incidence of infection with the protozoan Ceratomyxa drepanopsattae was 100% in both groups in both environments. In the case of the three remaining species (Tab. 6), the incidence of infection in fish from individual age groups differed insignificantly and did not display distinct tendencies.

3.5. Comparison of Parasitic Fauna from Two Regions of the North Atlantic

Analysis of the state of infection in blue halibut caught in Labrador and Barents Sea fishing grounds show that the parasitic fauna of this host display a large number of distinct characteristics in these regions. These differences were observed primarily in the incidence of infection (Tab. 2) and in the number of parasites of individual species found in fish from these fisheries (Tab. 2 and 7). In addition, qualitative differences were also present, although to a significantly lesser degree.

Tab. 4. Infection with Metazoa parasites in blue halibut in different age groups Labrador Region

Species of parasite		3+ n = 25	4+ n = 57	5+ n = 27	6+ n = 27	7+ n = 14	8+ n = 3	10+ n = 2
Entobdella sp.	deg.	0	1	0	0	0	0	0
	x̄		0,02					
	s		0,13					
Grillotia erinaceus, pl.	deg.	0	1	0	0	0	0	0
	x̄		0,02					
	s		0,13					
Scolex pleuronectis, pl.	deg.	2-34	1-37	1-47	1-57	1-23	2-11	26-43
	x̄	6,68	5,23	6,04	9,00	4,50	4,33	35,50
	s	9,20	7,58	9,95	12,31	6,54	5,86	13,44
Fellodistomum furcigerum	deg.	0	2	1	1-10	1-3	2	1-69
	x̄		0,04	0,04	0,70	0,36	1,33	35,00
	s		0,26	0,19	2,20	0,84	1,15	48,08
Stenacron vetustum	deg.	1-3	1-10	1-6	1-30	1-28	2-17	1-2
	x̄	1,08	2,07	1,67	5,44	8,79	8,00	1,50
	s	0,91	2,19	1,59	6,53	9,72	7,93	0,71
Steganoderma formosum	deg.	2	1	1-4	1-2	3-7	7-8	3
	x̄	0,08	0,02	0,30	0,22	1,36	5,00	1,50
	s	0,40	0,13	0,82	0,51	2,37	4,36	2,12
Heniurus levinseni	deg.	0	0	0	0	1-25	0	0
	x̄					1,86		
	s					6,67		
Derogenes varicus	deg.	1-4	1-6	1-4	1-9	1-23	2-18	1-4
	x̄	0,36	0,65	1,26	1,63	2,71	7,67	2,50
	s	0,91	1,04	1,26	2,00	5,94	8,96	2,12
Cenarchopsis metleri	deg.	0	0	0	1	0	0	0
	x̄				0,04			
	s				0,19			
Lecithaster gibbosus	deg.	1-3	1-4	1-3	1-7	1-2	1-2	1
	x̄	0,36	0,37	0,48	1,04	0,64	1,33	1,00
	s	0,76	0,77	0,75	1,63	0,74	0,58	0
Anisakis simplex, larva	deg.	1	1-3	1-2	1-6	1-3	1-6	3-4
	x̄	0,16	0,44	0,59	0,89	1,43	3,33	3,50
	s	0,37	0,76	0,75	1,50	1,45	2,52	0,71
Thynnascaris aduncа, larva III st.	deg.	1-9	1-15	1-13	1-42	1-16	1-9	2-5
	x̄	2,16	3,56	4,19	5,22	3,93	3,67	3,50
	s	2,29	2,81	3,23	8,09	4,76	4,62	2,12
Echinorhynchus gadi	deg.	0	0	1-5	1	1-9	6	7-48
	x̄			0,22	0,11	1,07	2,00	27,50
	s			0,97	0,32	2,46	3,46	28,99
Corynosoma strumosum, larva	deg.	0	0	0	0	1	0	0
	x̄					0,07		
	s					0,27		
Neobrachiella rostrata	deg.	1	1	1-3	1-4	1	0	1
	x̄	0,12	0,18	0,44	0,48	0,21		0,50
	s	0,33	0,39	0,70	0,89	0,43		0,71

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n - number of examined fish

deg. - degree of infection

x̄ - average degree of population infection (number of parasites per one infected individual in the examined population)

s - standard deviation

Tab. 5. Infection with Metazoa parasites in blue halibut in different age groups Barents Sea

Species of parasite		4+ n = 3	5+ n = 26	6+ n = 27	7+ n = 20	8+ n = 9	9+ n = 7	10+ n = 3	11+ n = 7	12+ n = 2	13+ n = 2
Nybelinia surmenicola, pl.	deg.				1	1					
	ā	0	0	0	0,05	0,11	0	0	0	0	0
	s				0,22	0,33					
Scolex pleuronectis, pl.	deg.	1	1	2-11	1-20	1-143	4-65	6-365	1-520	60	300
	ā	0,33	0,04	1,11	1,75	17,56	13,29	141,67	151,57	40,00	150,00
	s	0,58	0,20	2,78	4,51	47,86	23,61	194,90	250,04	56,57	212,13
Fellodistomum furcigerum	deg.		1-13	1-45	4-18	1	1-73	23	1-41	14	10
	ā	0	0,54	2,78	1,10	0,22	11,29	7,67	10,29	7,00	5,00
	s		2,54	9,23	4,08	0,44	27,27	13,28	16,98	9,90	7,07
Stenacron vetustum	deg.	1	1	2-5	7		1				
	ā	0,33	0,04	0,26	0,35	0	0,14	0	0	0	0
	s	0,58	0,20	1,02	1,57		0,38				
Hemiurus levinseni	deg.		1-2	1-8			16		1		
	ā	0	0,12	0,63	0	0	2,29	0	0,14	0	0
	s		0,43	1,90			6,05		0,38		
Derogenes varicum	deg.	1-53	1-124	1-195	1-15	1-12	1-12		1-10	32	9
	ā	10,00	27,50	23,33	2,40	2,89	4,14	0	3,86	16,00	4,50
	s	30,32	31,78	43,51	3,60	4,94	4,02		3,53	22,63	6,36
Lecithaster gibbosus	deg.		1	1	1						
	ā	0	0,08	0,04	0,05	0	0	0	0	0	0
	s		0,27	0,19	0,22						

Tab. cont'd on next page

Tab. 5. (cont'd)

Species of parasite		4+ n = 3	5+ n = 26	6+ n = 27	7+ n = 20	8+ n = 9	9+ n = 7	10+ n = 3	11+ n = 7	12+ n = 2	13+ n = 2
Anisakis simplex, larva	deg.	1-23	1-95	1-370	1-601	1-493	163-3713	322-3238	1-4168	235-867	1098-1101
	$\bar{a}$	8,67	13,08	35,48	108,10	156,00	1199,14	1311,33	1193,86	551,00	1099,50
	s	12,42	21,65	83,54	178,81	205,99	1366,84	1660,74	1307,57	446,09	2,12
Phocanema decipiens, larva	deg.	2	1-9	1-18	3-10	1	2	1-2	2-14	3-12	14
	$\bar{a}$	0,67	3,12	3,11	1,05	0,11	0,29	1,33	3,43	7,50	7,00
	s	1,15	2,52	4,44	2,82	0,33	0,76	0,58	5,00	6,36	9,90
Thynnascaris aduncа, larva III st.	deg.	2-6	1-57	1-42	2-61	9-91	1-27	4-37	3-392	24-84	9-17
	$\bar{a}$	4,00	13,85	15,74	19,45	36,22	8,86	18,67	70,14	54,00	13,00
	s	2,00	15,02	12,38	15,18	31,01	9,08	16,00	142,47	42,42	5,66
Echinorhynchus gadi	deg.			3						1	
	$\bar{a}$	0	0	0,11	0	0	0	0	0	0,50	0
	s			0,58						0,71	
Corynosoma strumosum, larva	deg.	2-3	1-13	1-25	1-13	2-15	1-10	1	1-24	1-62	20
	$\bar{a}$	1,67	2,85	3,33	3,65	5,89	4,00	0,67	10,57	31,50	10,00
	s	1,53	3,26	5,05	3,33	4,68	3,21	0,58	8,38	43,13	14,14
Corynosoma semerme, larva	deg.		1-2	1-2	1	1	2	1	1	1	
	$\bar{a}$	0	0,38	0,11	0,15	0,11	0,29	0,33	0,14	0,50	0
	s		0,75	0,42	0,37	0,33	0,76	0,58	0,38	0,71	
Neobrachiella rostrata	deg.	1	1-4	1-2	1-6	1-15	1-3	2-4	1-4	2	
	$\bar{a}$	0,67	1,04	0,33	0,50	1,78	0,57	2,00	1,43	1,00	0
	s	0,58	1,31	0,55	1,40	4,97	1,13	2,00	1,62	1,41	

n - number of examined fish

deg. - degree of infection

$\bar{a}$ - average degree of population infection (number of parasites per one infected individual in the examined population)

s - standard deviation

Four species of the group Protozoa were found in the North Atlantic. Two of them - Ceratomyxa drepanopsettae and Paramyxoproteus reinhardti - were present to a similar degree in the Barents Sea and in the Labrador region. Host infection with the protozoan C. drepanopsettae reached 100% in both areas. A dominant parasite in these regions was also P. reinhardti, the only difference being that the incidence of infection in the Labrador fishing grounds was 13% less in comparison with the invasion noted in the Barents Sea (Tab. 2). The remaining two species of protozoa Myxidium incurvatum and Ortholinea divergens decidedly predominated in the Labrador region (Tab. 2). The number of fish infected with spores of M. incurvatum was 41.2% higher here in comparison with the Barents Sea. The protozoa O. divergens can be grouped among the parasites which occur more frequently in the vicinity of Labrador (41.9% fish infected), even though they were rarely noted in fish from the Barents Sea. Differences in infection with these species were also evident in the degree of invasion (Tab. 2). 48/

Parasites belonging to the group Metazoa deserve special attention. A total of 18 species from this group were found in the North Atlantic. Some of the ones found sporadically were: Entobdella sp., Grillotia erinaceus, Nybelinia surmenicola and Genarchopsis müller̈i (Tab. 2 and 7). Neverthless, most of them were parasites which occurred somewhat more frequently or which were very often noted in these regions. These parasites can be

divided into two groups.

The first group includes species that were found in fish from one area only. These included the nematode Phocanema decipiens and the acanthocephalon Corynosoma semerme, found only in the Barents Sea, and the trematode Steganoderma formosum, found only in the vicinity of Labrador (Tab. 2 and 7). The next species - Corynosoma strumosum - was a common parasite of blue halibut in the Barents Sea (81.1% infected), whereas in the Labrador region this acanthocephalon almost never occurred (Tab. 2 and 7).

The second group included the remaining 10 species of Metazoa which were present in varying degrees in the infected blue halibut from the aforementioned regions. By far the greatest number of them reached a higher degree of invasion in the Barents Sea (7 species). One of the parasites in this group was the tapeworm Scolex pleuronectis; a lower incidence of invasion with this species was characteristic for blue halibut from the Barents Sea (Tab. 2). On the other hand, the average degree of infection with this species in the fish population exceeded the level of invasion in the Labrador region by over three times (Tab. 7). Moreover, the average degree of infection with this tapeworm was almost eight time higher in fish from the Barents Sea in comparison with invasion in the Labrador fishery (Tab. 2).

Tab. 6. Infection of blue halibut with protozoa (Myxosporidia) in different age groups

Species of parasite		3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+
		Labrador Region										
Ceratomyxa drepanopsettae	inc.	100.0	100.0	100.0	100.0	100.0	/3/x		/2/			
	deg.	sing.-v.numerous	sing.-massive	few-v.numerous	sing.-massive	few-v.numerous	few-numerous		few-massive			
Myxidium incurvatus	inc.	60.0	50.9	77.8	81.5	78.6	/2/		/2/			
	deg.	sing.-v.numerous	sing.-numerous	sing.-v.numerous	sing.-v.numerous	sing.-numerous	few-mod.numer.		single			
Ortholinea divergens	inc.	48.0	35.1	44.4	48.1	50.0	/1/		0			
	deg.	sing.-massive	sing.-massive	sing.-v.numerous	sing.-massive	sing.-moder.numer.	single					
Paramyxoproteus reinhardti	inc.	64.0	86.1	88.9	81.5	64.3	/2/		/1/			
	deg.	sing.-v.numerous	sing.-massive	sing.-massive	sing.-massive	sing.-massive	sing.-v.numerous		single			
		Barents Sea										
Ceratomyxa drepanopsettae	inc.	/3/	100.0	100.0	100.0	100.0	100.0	100.0	/3/	100.0	/2/	/2/
	deg.	moder.numer.-numerous	sing.-v.numerous	sing.-v.numerous	sing.-massive	few-v.numerous	sing.-numerous	sing.-moder.numer.	sing.-moder.numer.	sing.-few	few-moder.numer.	
Myxidium incurvatus	inc.	0	26.9	33.0	20.0	/1/	/1/	0	42.9	/2/	0	
	deg.		sing.-numerous	sing.-numerous	sing.-moder.numer.	single	single		single	sing.-few		
Ortholinea divergens	inc.	0	3.8	0	0	0	/1/	0	0	0	0	
	deg.		numerous				single					
Paramyxoproteus reinhardti	inc.	/3/	100.0	92.6	85.0	88.9	100.0	/3/	71.4	/2/	/2/	
	deg.	sing.-massive	sing.-massive	sing.-massive	sing.-v.numerous	sing.-numerous	sing.-massive	sing.-moder.numer.	sing.-numerous	sing.-few	single	

inc. - incidence of infection

deg. - degree of infection (cf. explanation in Tab. 2)

x - the number of infected fish in parentheses is given without calculating the percentage

Tab. 7. Infection of blue halibut with parasites of the group Metazoa in individual regions

Species of parasite	Labrador Region n = 155		Barents Sea n = 106		Bering Sea n = 7	
	$\bar{a}$	s	$\bar{a}$	s	$\bar{a}$	s
Entobdella sp.	0,006	0,08	0		0	
Grillotia erinaceus, pl.	0,006	0,08	0		0,14	0,38
Nybelinia surmenicola, pl.	0		0,02	0,14	27,43	30,85
Scolex pleuronectis, pl.	6,57	9,70	20,60	84,11	0,57	1,51
Aporocotyle simplex	0		0		1,71	4,54
Fellodistomum furcigerum	0,65	5,60	2,93	10,03	0,29	0,76
Stenacron vetustum	3,14	4,90	0,16	0,86	0	
Steganoderma formosum	0,35	1,23	0		0,43	0,53
Stephanostomum baccatum, met.	0		0		3,71	6,05
Homiurus appendiculatus	0		0		0,43	1,13
Homiurus levinseni	0,17	2,00	0,35	1,83	1,71	4,11
Brachyphallus crenatus	0		0		0,29	0,76
Derogenes varicus	1,23	2,60	14,81	29,22	0,57	0,79
Genarchopsis rölleri	0,006	0,08	0		0	
Lecithaster gibbosus	0,55	0,98	0,04	0,19	0	
Anisakis simplex, larva	0,68	1,15	272,42	690,30	917,00	2312,88
Phocanema decipiens, larva	0		2,34	3,60	6,29	4,50
Thynnascaris aduncа, larva III st.	3,77	4,41	21,23	40,25	43,00	108,49
Thynnascaris aduncа, larva IV st. et ad.	0		0,05	0,35	23,00	29,43
Echinorhynchus gadi	0,55	3,99	0,04	0,30	2,71	2,63
Corynosoma strumosum, larva	0,006	0,08	4,55	7,43	0,14	0,38
Corynosoma semerme, larva	0		0,21	0,53	0	
Hatschekia sp.	0		0		6,57	13,95
Neobrachiella rostrata	0,27	0,57	0,81	1,81	0	
Acanthochondria sp.	0		0		0,29	0,76

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n - number of examined fish

$\bar{a}$ - average degree of population infection

s - standard deviation

Among the trematodes in fish from the Barents Sea, Fellodistomum furcigerum, Hemiurus levinseni and Derogenes varicus were predominent. The incidence of infection with individual parasites in this water region was 7.55 - 74.5%, whereas infection with these trematodes in the vicinity of Labrador was significantly lower (1.3 - 52.3%) (Tab. 2). These differences became even more evident with respect to average degrees of population infection (Tab. 7). Infection with F. furcigerum was 4.5 times higher than the average degree of infection in the fish population of the Labrador region; invasion with H. levinseni was 2.1 times higher; and infection with D. varicus was 12 times greater than that of the fish population of the Labrador fishery. 50/

The nematodes Anisakis simplex and Thynnascaris adunca also occurred in great numbers in the Barents Sea (Tab. 2 and 7). The percentage of fish infected with larvae of Th. adunca in this area was somewhat higher (by 7.1%), yet the average degree of infection in the fish population was over 5 times greater than the invasion noted in the Labrador region (Tab. 7). In addition, individual adult individuals of this species were found in fish from the Barents Sea. Differences in the degree of infection with A. simplex were very large and were observed in all the parameters shown in Tables 2 and 7. Furthermore, these differences became very pronounced when comparing the degree of infection in different age groups (Tab. 4 and 5). The average degree of infection was 13.08 - 108.10 individuals in the 5+, 6+ and 7+

age groups of the fish population in the Barents Sea (Tab. 5), while the average ranged from 0.59 to 1.43 larvae per host in fish in the same age groups from the Labrador region (Tab. 4).

A higher degree of invasion with the crustaceans Neobrachiella rostrata was also found in the Barents Sea. The incidence of infection with this parasite in the Labrador region was 11.7% lower when compared to invasion in the Barents Sea (Tab. 2). The average degree of infection in the fish population was, however, three times lower in the Labrador region (Tab. 7).

A higher degree of infection in blue halibut from the Labrador fishery was only found in a few cases. For example, the trematode Stenacron vetustum was a common parasite in this region (78.1% infected), whereas it was rarely found in the Barents Sea (Tab. 2). In addition, the trematode Lecithaster gibbosus was a more frequent parasite (35.5% infected) in the vicinity of Labrador than in the Barents Sea, where it was found very rarely (Tab. 2). Differences in infection with the above parasites became even greater when comparing the average degrees of infection in the fish population (Tab. 7). Infection of blue halibut with the species L. gibbosus was almost 14 times greater in the Labrador region, and infection with S. vetestum reached a level which was 19.6 times greater in comparison with the level of infection in fish from the Barents Sea. Moreover, infection with the acanthocephalon Echinorhynchus gadi, which is rarely found in the North Atlantic, was almost 14 times greater in the

Labrador fishing grounds than in the Barents Sea (Tab. 7). The difference in incidence of infection was small in this case, i.e., only 5.8% greater than in the Labrador region (Tab. 2).

Statistical elaboration of data for 10 species of Metazoa was carried out to check the reliability of indicated differences in infections between blue halibut from the Labrador fishery and those from the Barents Sea. This analysis fully corroborated the distinct characteristics shown above and showed the existence of significant differences in the number of individual parasites in the aforementioned areas. A statistically significant and higher level of infection in the Barents Sea was shown with respect to the following species: Scolex pleuronectis, Fellodistomum furcigerum, Hemiurus levinseni, Derogenes varicus, Anisakis simplex, Thynnascaris adunca and Neobrachiella rostrata. On the other hand, the number of trematodes Stenacron vetustum and Lecithaster gibbosus, as well as that of the acathophalon Echinorhynchus gadi, was significantly higher in the Labrador region. Only fish belonging to three groups (5+, 6+ and 7+) were taken into consideration in both areas for statistical elaboration of data on A. simplex since this material was suitable for quantitative comparisons and, in addition, the effect of the host's age on the degree of infection with this parasite was ruled out. 51/

3.6. Initial Studies of Parasitic Fauna of Blue Halibut from the Bering Sea

The main characteristics of the parasitic fauna of blue halibut from the Bering Sea were a rather large variety of species and a differentiated degree of invasion intensity. All in all, 21 species of parasites were found in the examined material; they belonged to the following systematic groups: Protozoa (3 species), Cestoda (3), Trematoda (8), Nematoda (3), Acanthocephala (2) and Crustacea (2 species).

Because of the frequency of occurrence, the dominant parasites in this water body were Nybelinia surmenicola, Anisakis simplex, Phocanema decipiens and Thynnascaris adunca (Tab. 2). Infection with these parasites was 100% in the fish population. The greatest number of larvae per host was attained by A. simplex: up to 6162 specimens in one fish. This species was situated mainly in the body cavity; the largest concentrations of nematodes were found in stomach walls (Tab. 3). These parasites were also found relatively often in the stomach integument muscles. A total of 612 individuals were isolated from the muscles, which was 9.5% of the total number of A. simplex larvae found in the examined samples. The remaining species showed a smaller degree of invasion (Tab. 2), yet their absolute numbers were also high, eg. infection with third-stage larvae of Th. adunca reached 289 individuals in one fish. As in the case of A. simplex, these larvae were present chiefly in the stomach;

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only 4 individuals were found in muscles (Tab. 3). In the case of Th. adunca, adult forms and fourth-stage larvae were found only in the intestine of the halibut. The nematodes Ph. decipiens, in contrast to findings in fish from the Barents Sea, established themselves mainly in the muscles on the abdominal side or in the dorsal part of the thorax (Tab. 3). Plerocercoids of the tapeworm N. surmenicola were found most often in the stomach walls (93.3%), rarely in other organs of the body cavity (5.7%) and only sporadically in muscles (1%).

The following also proved to be common parasites of the fish examined in this study: Ceratomyxa drepanopsettae, Stephanostomum baccatum and Echinorhynchus gadi (Tables 2 and 7). Infection with these species reached 71.4 - 85.7%. The protozoa C. drepanopsettae were found in the gall bladder, metacercariae of S. baccatum were established in muscles located principally at the base of the fins, while the acanthocephalons E. gadi lived in the intestine.

Among the more frequent parasites of blue halibut in the Bering Sea were: protozoa Myxidium incurvatum, found in the gall bladder; the trematode Steganoderma formosum, occurring in the intestine; the trematode Derogenes varicus, found in the stomach; and the crustacean Hatschekia sp., found on the gills and, in one case, on the abdominal fin (Tab. 2 and 7). Infection with the above protozoan and trematodes was 42.9% in the fish population (Tab. 2), and reached 57.1% in the case of the crustacean.

The trematode Hemiurus levinseni, which parasitized in the stomach, was not noted as often (28.6% infected). The degree of invasion with this species was a maximum of up to 11 individuals in one fish.

The remaining 9 parasitic species were found even less often (Tab. 2 and 7). These included protozoa of Paramyxoproteus reinhardti from the urinary bladder, plerocercoids of Grillotia erinaceus tapeworms from the stomach wall, and plerocercoids of Scolex pleuronectis from the intestine. The trematodes included Aporocotyle simplex, living in the arterial cone of the heart; Hemiurus appendiculatus and Brachyphallus crenatus, found in the stomach; and Fellodistomum furcigerum, located in the intestine. Among the acanthocephalons, only one larva of Corynosoma strumosum was found in the intestine wall. Similarly, only one female and one male of the crustacean Acanthochondria sp. were found parasitizing on the gills.

4. DISCUSSION

4.1. Morphology and Systematic Affiliation of Some Parasites

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4.1.1. Protozoa

According to the available literature, two species of the genus Ceratomyxa Thelohan, 1892 occur in the gall bladder of blue halibut. Of the two, the one noted most often was C. drepanopsettae (Polyanskii, 1955; Shulman, 1966; Zubchenko, 1980). Occurrence of the second species - C. ramosa Awerinzew, 1907 - is

rather characteristic only for white halibut (Kudo, 1919; Shulman, 1966). The presence of C. ramosa in blue halibut has only been mentioned by Zubchenko in his study (1980). There were no significant differences in the spores of the genus Ceratomyxa found in the individuals of blue halibut from the regions of Labrador, the Barents Sea and the Bering Sea which were examined for this study. Their morphology and dimensions correspond most closely to descriptions of the species C. drepanopsettae. The descriptions given to date have not, however, been too exact. According to figures contained in the studies of Kudo (1919) and Shulman (1966), this species has distinctly elongated, pear-shaped polar capsules, whereas my own material showed that the shape of the polar capsules was always nearly spherical (Fig. 2 and 3).

The next parasite noted by Zubchenko (1980) in the gall bladder of blue halibut from the North-western Atlantic was Myxidium sphaericum Thelohan, 1895. The author, however, does not include a description or a diagram of these sporozoa. These protozoa had been found earlier only in fish of the genus Belone (Kudo, 1919; Pogorelceva, 1964; Shulman, 1966). My own studies, based on a large amount of material, revealed the presence of another species: M. incurvatum (Fig. 4), which differs from M. sphaericum by the completely different shape of its spores. The protozoa M. incurvatum are common parasites of many marine fish including, among others, some flatfish (Kudo, 1919;

Pogorelceva, 1964; Shulman, 1966). This species was found for the first time in blue halibut in materials examined for this study.

The sporozoa Ortholinea divergens were found parasitizing in the urinary bladder of the examined fish. This species is mentioned by Zubchenko (1980) in conjunction with blue halibut. 54/ Certain inconsistencies regarding the shape of polar capsules are noticed when comparing the morphology of the spores found in my material and data contained in the literature (Kudo, 1919; Shulman, 1966). These authors state that the polar capsules are pear-shaped (rather distinctly elongated). My own observations show that they are pear-shaped and spherical (Fig. 5). Moreover, the thickness of the spores in my material is somewhat smaller (4.8 - 6.8 μm) than that given in the literature noted above (8 μm). According to studies of Moser and Noble (1977), the thickness of spores of this species is 6.5 - 8.0 μm. These authors found the protozoa Coelorhynchus coelorhynchus carminatus (Macrouridea) in the gall bladder; these protozoa had only been found in the canaliculi of the kidneys and in the urinary bladder until then.

Two species of sporozoa are also known to exist in the urinary bladder of blue halibut. One of them - Schulmania quadriolobata - is described as a new genus and species by Kovaleva et al. (1983), while the second one - Paramyxoproteus reinhardti - is described by the author. The characteristics

which differentiate these protozoa are given in a study by Wierzbicka (1986). It is surprising, however, that no spores resembling the species S. quadriolobata were found in my own (relatively extensive) material. On the other hand, spores described as P. reinhardti were very often noted.

4.1.2. Cestoda

Larvae of the tapeworms Scolex pleuronectis Muller, 1788 (= S. polymorphus Rudolphi, 1819) have been found in blue halibut by many researchers (Polyanskii, 1955; Mamaev et al., 1963; Zubchenko, 1980; Reimer, 1981). These authors do not include descriptions or diagrams of the observed parasites. S. pleuronectis is probably a collective name for larvae of different species of the order Tetraphyllidea (Strelkov, 1960; Zhukow, 1960; Dubinina, 1962; Grabda, 1981). In his study of fish from the Japan Sea and waters of the Southern Kurile shallows, Zhukov (1960) found as many as four types of these larvae which were differentiated according to their adhesive organs: 35 species in the alimentary canal, and 21 species in the gall bladder. One of these forms - Hemitripterus villosus (Cottidae) from the gall bladder - resembles the plerocercoids observed in my material. Only one type of larva (Fig. 6) was found in the examined blue halibut individuals from fisheries of the North Atlantic and the Bering Sea. They are very similar morphologically to the plerocercoids described in the alimentary canal of the capelin

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(Mallotus villossus) (Osmeridae) from the North Atlantic (Palsson, Beverley-Burton, 1984). The dimensions of adhesive organs also lie within this range with only the length and width of larvae from blue halibut being somewhat larger in comparison with data given by Palsson and Beverley-Burton.

4.1.3. Crustacea

A detailed description of females of Hatschekia hippoglossi (Cuvier, 1830) illustrated with numerous diagrams is given by Kabata (1979). His studies show that this parasite is specific to white halibut and occurs only in the North Atlantic. In his study, Kabata also includes a schematic diagram and a very short fragmentary description of the male according to Scott and Scott (1919). In spite of the large number of fish studied (697 individuals, which included 186 infected with females), this author was unable to find males of this species. The material of Zubchenko (1980) also comes from the North-western Atlantic; he observed these crustaceans mainly on white halibut and, in one case, on blue halibut. Zubchenko does not, however, include a description of these parasites.

The Hatschekia sp. collected in my material come from blue halibut individuals caught in the Bering Sea fishing ground of the Pacific Ocean. The morphology of the females found in the material is very similar to that of H. hippoglossi described by Kabata (1979). Some rather significant differences were

observed, however, with respect to certain appendages. According to the description given by Kabata, the end of the first pair of antennae (the fifth and end segments) is equipped with 12 different setae, while the crustaceans found in blue halibut from my material had 15 different setae on the end of this antennae (Fig. 10a). Moreover, according to Kabata (1979) the endopodite of the first pair of mandibles in the female is equipped with one delicate, central, seta-like process located between two protuberances. The central process in my material is significantly longer and wider. In addition, there is a lateral, seta-shaped process on the endopodite near the central part (Fig. 11b) which is not mentioned by Kabata. There are 4 longer setae on the end of the endopodite of the first pair of truncal limbs according to data presented by Kabata. My studies showed that these parasites have only 3 setae on the tip of this appendage (Fig. 12a). Moreover, the end and the lateral processes of the uropods in the blue halibut individuals studied here are covered with thin hairs which are distinctly visible (Fig. 13b); this is not mentioned in the description given by Kabata and is not noted in his diagram. In addition, the overall length of females found in blue halibut was 6.0 - 11.5 mm, while crustaceans from white halibut were 3.9 - 5.8 mm in length. It should be mentioned that the morphological characteristics differentiating females found in white halibut from those found in blue halibut were also observed in the appendage structure of the male.

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It is possible to assume that the crustaceans found in blue halibut belong to a new species which has not yet been described; this assumption is based on the above differences and the occurrence of this parasite on other hosts and in altogether different bodies of water. Only examination of original material from blue halibut would make it possible to decide whether this suggestion is correct or whether the description of the females included in this study should be treated as a re-description of the species Hatschekia hippoglossi. Moreover, the detailed description of the males included in this study constitutes a complement to missing data with respect to the morphology of these crustaceans.

4.2. Formation of Parasitic Fauna and its Dependence on Fish Age

The dependence of parasitic fauna on fish age is a phenomenon which has been noted by many researchers for a long time. This becomes particularly evident with respect to infection in migratory fish which change their habitat. Heitz (1919) is one of many who studied the parasitic fauna of salmon (Salmo salar) and divided it into river fauna, river and marine fauna, marine and river fauna, and typically marine fauna. Moreover, Dogel (1936) wrote about changes in the parasitic fauna of the eel (Anguilla anguilla) at various stages of its life. This author noticed that there were absolutely no parasites in the eel in the first 3 - 4 years of its life and in the final months of

its life, i.e., when migrating to spawning areas. The presence of parasites which were characteristic for fresh water were found in females during the remaining periods, whereas the presence of fresh-water and marine parasites were found in males. In the case of migratory fish with two habitats, parasitic fauna is affected not only by the age of the fish but also and above all by the altogether different surroundings in which these fish live for a certain period of their life. Consequently, there is a greater dependence on ecological factors than on fish age in such instances. When this is taken into consideration, the examples given here do not lend themselves very well to comparison with the parasitic fauna of blue halibut. 57/

The formation of parasitic fauna and its dependence on the age of fish living only in fresh water has been described in many studies. In one of them, Gorbunova (1936) examined pike (Esox lucius) in the 0+ - 4+ age group (individual fish in the 5+ - 11+ age group) and roaches (Rutilus rutilus) from 0+ to 4+ years of age in one of the lakes of Karelia. Her observations showed that infection with some parasites increases along with the age of the host, but that there were some species for which the intensity of the invasion did not change or dropped together with an increase in fish size and age. Data prepared by Byhovska (1940) on parasitic fauna of perch (Perca fluviatilis) also come from two lakes of Karelia. She found that fish in the 0+ age group showed the lowest qualitative degree of infection while three-year-old

perch showed the highest. Studies carried out by Polyanskii and Shulman (1956) emcompassed 7 species of fish from lakes in the southern part of Finland and Karelia SRR. The included the formation of parasitic fauna from the first days or months after hatching until the age of 1+ or, less frequently, 2+. Their analysis showed that infection in the intial period of life occurs with parasites having a simple development cycle (Protozoa, Monogenea) and with those which actively infiltrate the host (cercariae). Moreover, the number of species increases globally together with growth of the host and the range of parasites begins to include those that the host becomes infected with through intermediate hosts. Kulemina (1969) obtained similar observations when carrying out studies on larvae and fry (0+ - 1+) of four species of Cyprinidae and two species of Percidae from the Seliger Lake. This author also noticed that the decrease of infection with ectoparasites which sometimes takes place in the autumn period is seasonal in character.

Studies on marine fish with a single habitat are much closer to my area of study. Polyanskii and Shulman (1956) presented interesting findings on this subject. Among the fish they studied were cod (Gadus morhua), coal-fish (Pollachius virens), and scorpion sculpin (Myoxocephalus scorpius) from the Barents Sea in the 4 - 5 month to 1+ year age group, and herring (Clupea harengus) from the White Sea up to 3+ years of age. These authors found certain regularities in the dynamics of parasitic

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fauna in young fish which were, however, different than those found in fresh-water surroundings. Their study showed that during the first period of life marine fish are infected by species primarily through eating intermediate hosts, and later by parasites with a simple development cycle (Ciliata, Monogenea). This infection process is connected with a large degree of spatial isolation between young individuals and older fish in the marine habitat. In addition, young individuals live in different ecological conditions which sometimes cause the appearance of the so-called "larval parasites" which partially or completely disappear in older age groups. The observations of Polyanskii and Shulman cannot be compared with my results because the analysis of parasitic fauna of blue halibut in my material encompasses only fish in the 3+ age group.

Other authors have also written about the interdependence between parasitic fauna of marine fish and fish age. Rae (1958) found that young individuals of white halibut from the North Atlantic were not infected with plerocercoids of Grillotia erinaceus. The level of infection with these larvae was also low in individuals of white halibut under 90 cm in length. Invasion intensification occurred only in older fish groups. In my material, I found only a single larva of this species in the 4+ age group of fish from the Labrador fishing grounds and in one fish in the 14+ age group from the Bering Sea. This indicates that infection of blue halibut with these larvae is random.

On the other hand, Mehl (1970) noted a higher degree of infection with plerocercoids of Gymnorhynchus thyrsitae Robinson, 1959 in atun (Thyrsites atun) over 85 cm in length living in the region of New Zealand. Similar observations on infection with this tapeworm in atun were given by Wierzbicka and Gajda (1984). The literature most often presents data which indicate that invasion with Nematoda larvae increases with the age of the fish (Khalil, 1969; Grabda, 1974, 1976; Wootten and Waddell, 1976 - 77; Piasecki, 1982; and others). It should be noted that statistical methods were not used in the studies mentioned above for the purpose of verifying this interdependence and that the results of these authors are therefore not always comparable to my data.

Studies of blue halibut aged from 3+ to 11+ (single individuals aged 12+ and 13+) showed that the degree of infection with parasites from the groups Protozoa and Metazoa is not dependent on the age of this fish. Anisakis simplex was the only species found where the number of parasites increased with the age of the host. Statistically significant differences in infection with this parasite were found in the 3+ - 6+ age groups of fish from the Labrador fishing grounds and in the 7+ - 9+ age group of fish from the Barents Sea. The increase in degree of invasion is closely connected with the biology of A. simplex and the diet of the host since the composition of its nourishment changes together with its age and size.

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The young forms of blue halibut, which begin life as bottom fish, feed on pelagic crustaceans of which the most significant are Euphausiacea, Decapoda (mainly Pandalus borealis), Mysidacea (Boreomysis sp.) and Amphipoda (Themisto sp.). Larger individuals feed almost exclusively on fish or larger crustaceans (Andriyashev, 1954; Krzykawski, 1975). Capelin is the dominant species of fish eaten by young halibut; on the other hand, polar codling (Boreogadus saida) is the dominant species in cooler water closer to the Arctic regions. In addition, studies carried out by Haug and Gulliksen (1982) showed that blue halibut in the 1 - 6 age group at coastal fisheries of Western Spitzbergen feed mainly on fish (88.5% of food eaten) and crustaceans (19.5%), and that polar codling constitutes 62.1% of their nourishment.

The development cycle of Anisakis simplex was described in detail by Grabda (1973a, 1981) based on extensive literature. The first intermediate hosts of this nematode are plankton crustaceans of the order Euphausiacea; second-stage invasion larvae begin living in the body cavity of these crustaceans. Infection of young blue halibut individuals therefore takes place when they eat crustaceans of this group since, as mentioned above, crustaceans are one of the main elements of nourishment for halibut during this period of life. Larger blue halibut become infected in most cases by eating planktonophagous or predatory fish containing third-stage invasion larvae. It should be emphasized that capelin is the predominant food of older

individuals of blue halibut in many regions; among other things, capelin feeds on the crustaceans Euphausiacea (Andriyashev, 1954). While performing dissections of blue halibut, frequent observations were made of larval penetration from still indigested fish which served both as nourishment and the parasites' route of penetration into a new host. It was possible to study this phenomenon because the specimen fish were frozen to a temperature of -20°C immediately after being caught and this procedure killed the larvae during their migration. After thawing, when the fish (food) was being removed from the stomach of the halibut, it was possible to observe nematodes whose one end was still embedded in the body integuments of the eaten fish while the other end was entering the stomach wall of the blue halibut. These larvae remain in the body cavity or muscles after entering these areas and undergo secondary encysting. Because of this, more and more A. simplex accumulate in blue halibut as they grow older since these fish serve as a second indirect host and are paratenic hosts at the same time. 60/

A similar interdependence was observed with respect to infection of atun with larvae of A. simplex in the region of New Zealand (Wierzbicka, Gajda, 1984). These authors noted that the average degree of infection in the population was two times higher for fish over 80 cm in length. Wootten and Waddell (1976-77) described the intensity of invasion with these nematodes and its relationship to the age and length of cod and

whiting (Merlangius merlangus) in the vicinity of Scotland. Moreover, studies carried out by Grabda (1976) showed that the incidence of infection with these larvae in Baltic cod clearly increases in fish 70 - 75 cm in length. Furthermore, Grabda (1974) found that the incidence and degree of infection in Baltic herring increases successively with its size, whereas no A. simplex were found at all in herring less than 20 cm in length. Results of infection of herring from the North Sea obtained by Khalil (1969) were approximately the same, the only difference being that single nematodes occurred in fish approx. 5 cm in length.

The accumulation of A. simplex larvae in older fish unquestionably makes it easier for them to reach their final hosts, which are marine ichthyophagous mammals of the catacean order (mainly dolphins) and pinnipedians (seals) (Grabda, 1973a, 1981).

The development of the nematode Phocanema decipiens found in blue halibut of the Barents Sea and the Bering Sea is identical to that of A. simplex; the only difference is that the first intermediate hosts of Ph. decipiens are Nereis, Amphipoda, Isopoda, Mysidacea and other crustaceans (Myers, 1960). Third-stage larvae eaten together with fish (second intermediate host) can also enter the body cavity and muscles of predatory fish. As in the case of A. simplex, accumulation of Ph. decipiens larvae sometimes occurs in older fish. Studies of Wootten and Waddell (1976-77) showed that the level of invasion with these nematodes

increases together with the age of cod. This tendency was not noted with respect to infection of the blue halibut examined for this study. This can be explained by the different feeding habits of this host. As noted above, the dominent element in its nourishment is capelin which, in turn, feeds mainly on the crustaceans Euphausiacea which are the intermediate host of A. simplex. Because of this, the number of nematodes of this species increases together with the age of blue halibut. On the other hand, infection with larvae of Ph. decipiens takes place through other organisms which play a smaller part in the nourishment of this fish; for this reason, infection with this parasite is rather random in character. Studies conducted by Palsson and Beverley-Burton (1984) also support this explanation since larvae of Ph. decipiens were not found in capelin from the North Atlantic, whereas the occurrence of A. simplex in this host was noted. 61/

The nematodes Thynnascaris adunca found in blue halibut have a somewhat different biology. The first intermediate hosts of this parasite are the copepods Acartia bifilosa and Eurytemora affinis (Markowski, 1937). The adult forms parasitize in the alimentary canal of predatory fish. Data in the literature show that larval infection of planktonophagous and predatory fish which are also second intermediate hosts can intensify along with the size of the host. This has been indicated by studies of Baltic cod conducted by Grabda (1976) and studies of sprat (Sprattus sprattus) from the North Sea in the 1 - 4 age group

carried out by Khalil (1969). However, the same author also noticed that the level of infection with these larvae in herring from the North Sea dropped as the fish grew older. According to Grabda (1976), the increase in the incidence of infection with third-stage larvae of Th. adunca is connected with the ever-growing amount of fish (larval hosts) in its diet. My own material did not show significant differences with respect to age in the level of infection of blue halibut from both fishing grounds with third-stage larvae of Th. adunca. Moreover, examination of the alimentary canal of this host from the Bering Sea showed the presence of rather numerous fourth-stage larvae and adult individuals (males and females); in fish from the Barents Sea, single fourth-stage larvae and adult forms were found. Sulgostowska and Jerzewska (1987) also indicated the presence in all seasons of fourth-stage larvae and adult nematodes of Th. adunca in the alimenatary canal of an eel (Zoarces viviparus) from the vicinity of Hel (Baltic); third-stage larvae were present in the liver at the same time. It is therefore possible to assume that third-stage larvae of Th. adunca eaten by the fish do not always infiltrate the body cavity, as some authors have suggested, but remain in the alimentary canal and reached sexual maturity after moulting two times. Janiszewska (1937, 1938) presented similar observations and conclusions on the basis of studies conducted on flounder (Platichthys flesus) from the Puck Gulf (Baltic). This is therefore one of the reasons why

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the intensity of invasion with third-stage larvae does not occur together with an increase of age in blue halibut.

My observations on the presence of the trematodes Digenea in blue halibut are consistent with the findings of Køie (1983), who studied dab (Limanda limanda) from 5 to 35 cm in length which came mainly from waters close to Denmark. This author made a thorough study of infection with the trematodes Fellodistomum furcigerum and Derogenes varicus, among others; these are species which also occurred in blue halibut. Her data show that infection with the trematodes F. furcigerum and D. varicus in dab, as with the other three species of Digenea, maintains a similar level or shows small fluctuations (which are probably not statistically significant) in different size groups of this host. Monascus filiformis (Rudolphi, 1819) was the only species for which the incidence and degree of infection dropped rather clearly with an increase in dab size.

The statistically established lack of a relationship between the age of blue halibut and infection with the remaining species of the group Metazoa is doubtlessly related to the feeding habits of the host and the biology of the parasites; this is also true for the lack of distinct differences in the incidence of invasion with parasites of the group Protozoa. A more detailed interpretation of these results is very difficult because the development cycles of parasites found in this host have not been studied in detail; moreover, there are no data on the composition of

the food eaten by the blue halibut and the fauna in the fishing grounds from which the examined fish came.

4.3. Parasitic Fauna of Blue Halibut from the North Atlantic in Relation to Region (Fishing Ground)

Examinations carried out for this study on blue halibut showed that a rather diverse group of species and a very different level of infection with individual parasites were characteristic for the parasitic fauna of this host in the North Atlantic. Altogether, 22 species of parasites were found in the blue halibut individuals from the two areas examined in this study; this included 19 species from the Labrador fishery and 18 from the Barents Sea. The most numerous group of parasites was Trematoda (7 species). The next most numerous group was Protozoa (4 species). Of the remaining groups - Cestoda, Nematoda and Acanthocephala - 3 species of each were found, while one species of each was found in the case of Monogenea and Crustacea. The number of parasites found in my material was somewhat higher in comparison with data contained in the literature on this host. According to other authors, blue halibut from the North Atlantic contained anywhere from 6 species of parasites in the Barents Sea (Polyanskii, 1955) to 16 in the north-western region (Zubchenko, 1980). The modest number of parasites given by these authors is probably a result of the relatively small number of fish studied, especially with respect to the Barents Sea.

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Another characteristic of the parasitic fauna in the fish examined for this study was the differentiation between the blue halibut populations from two regions of the North Atlantic which were far away from each other. Infection in hosts from the vicinity of Labrador and the Barents Sea showed both large quantitative differences and, to a lesser extent, qualitative differences. When the very rare parasites were not included (4 species), it was found that among the 22 species only the protozoa Ceratomyxa drepanopsettae and Paramyxoproteus reinhardti occurred in both fisheries with a similar degree of intensity (Tab. 2). The remaining 16 species showed very significant differences. The level of infection in blue halibut from the Barents Sea was globally somewhat higher. Three species were found in this water body which were not noted in principle in the Labrador region, while one species occurred only in material from the vicinity of Labrador (Tab. 2). Moreover, a higher level of infection was found in blue halibut from the Barents Seas with respect to 7 species of the group Metazoa, while in the Labrador region there was a decidedly higher degree of infection with 2 species belonging to Protozoa and 3 from the group Metazoa (Tab. 2 and 7).

Differences in infection of blue halibut from the Barents Sea and the Labrador region is undoubtedly connected with different habitat conditions which affect the formation of parasitic fauna by determining the presence of intermediate or final hosts,

among other things. In my material, 4 species of parasites were found whose final hosts are marine mammals. These are larvae of the nematodes Anisakis simplex and Phocanema decipiens and larvae of the acanthocephalons Corynosoma strumosum and C. semerme. Three of them - Ph. decipiens, C. strumosum and C. semerme - occurred almost exclusively in individuals of blue halibut from the Barents Sea. The incidence of infection with these parasites reached 15.2 - 81.1%, whereas only one larva belonging to C. strumosum was found in material from the Labrador fishing grounds (Tab. 2). Furthermore, infection with larvae of A. simplex in fish from the Barents Sea was very high, while in the Labrador region these nematodes were found considerably less frequently (Tab. 2 and 7). It is therefore possible to assume that the higher level of infection with these parasites in blue halibut from the Barents Sea is related to the greater number of marine mammals in this habitat, among other things. 64/

A more detailed explanation of the established differences in the level of infection with different parasities in blue halibut from the vicinity of Labrador and the Barents Sea is impossible for the same reasons given when describing the parasitic fauna of this host and its dependence on fish age (pp. 80 - 82).

To date, studies on the parasitic fauna of blue halibut have consisted mainly of cataloguing species. Only Reimer (1981), using material from two different regions, has also pointed out

certain differences in the makeup of parasitic fauna in this host. He noticed that a somewhat larger number of species occurred in the Davis Strait (13 species) in comparison to the Bear Island area (9 species). He indicated that these differences affected rarely occurring parasites (2 - 9%) and pointed out that there was still a possibility of discovering them in the North-eastern Atlantic. His study also presented the incidence and degree of infection in blue halibut from the regions studied; he did not, however, analyze these parameters.

Comparison of the results of my research with those of Reimer (1981) reveals that it is possible to notice a certain concurrence. Infection of blue halibut from the Bear Island area is comparable to data from the Barents Sea in several respects. It is also possible to speak about similarities in the infection of blue halibut from the Davis Strait and the Labrador fishing grounds, primarily with respect to larvae of Anisakis simplex and Corynosoma strumosum (parasites whose final hosts are marine mammals) and the crustacean Neobrachiella rostrata. As in the Barents Sea, these species occurred in greater numbers in fish from the vicinity of Bear Island. Additionally, my material showed that the trematode Stenacron vetustum was a common parasite in the Labrador fishery, yet it was rarely noted in the Barents Sea. Reimer also found these trematodes (although not in numerous quantities) only in the Davis Strait. Plerocercoids of the order Grillotia also should be mentioned in conjunction with

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this comparision since the author found them only in the Davis Strait. Similarly, my own material showed that they were found sporadically only in the Labrador region. Reimer did not include the age or the length of the examined fish, thus comparison with his results could give rise to certain reservations. In spite of this, the examples given here regarding some of the similarities between the parasitic fauna of blue halibut from the Barents Sea and the vicinity of Bear Island, and from the Labrador fishing grounds and the Davis Strait seem to be substantiated ecologically because these regions are located relatively close to one another. The assumption should also be made that the individuals of blue halibut studied by Reimer came from fishing catches and were, at least to a certain extent, numerically similar to my total material. One of the interesting elements of the study conducted by Reimer (1981) is that he noted, among others, the occurrence of the trematode Bucephalopsis gracilescens (Rudolphi, 1819) and larvae of the tapeworm Bothriocephalus sp. only in individuals from the Davis Strait. This indicates that the parasitic fauna of blue halibut has a certain distinct character in this region. It should also be noted that Reimer found the trematode Lecithaster confusus Odhner, 1905 and larvae of the nematodes Phocascaris sp. in individuals of blue halibut from both regions. These parasites were not noted in my material. On the other hand, what I did find in my material was another species of trematodes from this genus - L. gibbosus.

Infection with these trematodes in blue halibut from the Labrador fishery was similar to the invasion of L. confusus in the Davis Strait, and infection of fish in the Barents Sea was similar to that found in fish in the vicinity of Bear Island.

Comparisons of my data on fish from the Barents Sea with results obtained by Polyanskii (1955), who examined only two individuals of blue halibut from this body of water, make it possible to state that he found the most common parasites occurring in this host in this region. These are Cerotomyxa drepanopsettae, Scolex pleuronectis, Derogenes varicus, Thynnascaris adunca (larvae and adult forms) and larvae of Anisakis sp. In addition, he mentions the presence of the trematodes Genarchopsis mülleri, which occurred sporadically only in the vicinity of Labrador.

The parasitic fauna of blue halibut from the vicinity of Labrador described in this study approximates that of Zubchenko (1980) to a certain degree. The fish he studied came from bodies of water in the North-west Atlantic from Newfoundland to Baffin Island and, because of this, maybe also from the fishing grounds of Labrador. Certain similarities between my results and those of Zubchenko consisted of approximately the same degree of infection in halibut with such parasites as Scolex pleuronectis, Derogenes varicus, Lecithaster gibbosus and Anisakis sp. The larvae Grillotia erinaceus and Corynosoma strumosum were parasites which were rarely noted in his study and which also

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occurred sporadically in my material from the Labrador region. Infection with both protozoa and larvae of Thynnascaris adunca was globally smaller in Zubchenko's material. The trematodes Stenacron vetustum, a frequent parasite in the Labrador fishing grounds, can be treated as a distinct characteristic of my results in relation to those of Zubchenko (1980) since none were noted in his study. He did, however, note the presence of this species in the North-west Atlantic quite often in individuals of white halibut and other Pleuronectidae. The differences observed in infection with this parasite in blue halibut may be due to the small number of fish studied by Zubchenko or the result of collecting material from another fishery with somewhat different ecological conditions.

Many authors have written about the interdependence between parasitic fauna in marine fish and environmental conditions. Among them, Gibson (1972) studied flounder from three regions of the coastal waters of Scotland within a range of approx. 30 miles, i.e., from two estuaries and a zone of open sea close to Aberdeen. This author showed that the schools of examined flounder had a different characteristic degree of infection with individual parasites and particularly with those species which constitute so-called biological indicators which, according to him, consisted mainly of the trematodes Podocotyle sp. and Zoogonoides viviparus (Olsson, 1868). Gibson's explanation for differences observed in the parasitic fauna of examined fish is

that in each of the above areas the flounder are exposed to different environmental conditions which means that there is a different intensity in of occurrence of intermediate hosts. Among his observations, he noted that schools of molluscs of the order Littorina, among which the amphipods Corophium volutator lived, were commonly present only at the mouth of the Ythan River. These molluscs, followed by Corophium, are intermediate hosts of the trematodes Podocotyle which occurred in very great quantities in the examined flounder taken only from that estuary. On the other hand, these trematodes were rarely found in fish from the mouth of the Dee River or from the zone of open sea.

Gluhova (1956) also noticed a difference in the parastic fauna of flounder and Liopsetta glacialis from bays of the White Sea. She found that marine species were predominant in Kandalaksha Bay, while estuarial and typically fresh-water parasites occurred in Dvina Bay, which is the area with the highest amount of fresh water. In the Onega Gulf, in turn, Gluhova found some boreal forms not noted in individuals from other regions. On the basis of these results, the author came to the conclusion that the examined fish form local colonies which live in well-defined regions. Kulachkova (1977) found that infection with parasites of Monogenea in herring from bays of the White Sea also showed distinct differences and could serve as one of the indicators confirming the presence of local colonies of herring in this environment. Similarly, comparisons made by Nikolaeva (1963a)

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between the parasitic fauna of fish from various regions of the Black Sea suggest the existence of three different colonies of anchovy (Engraulis encrasicholus), which are differentiated by the degree and incidence of infection, and four colonies of Mediterranean carangid (Trachurus mediterraneus ponticus), which are differentiated by the makeup of parasitic species. Moreover, Nikolaeva (1963b) found that there was a differentiation in the parasitic fauna of Spicara smaris in the Black Sea from the vicinities of the Crimea and the Caucasus.

The authors of the studies mentioned above described the parasitic fauna in fish from various areas located within one sea. The publication of Prost (1967), among others, is an example of research comparing the parasitic fauna of marine fish from water bodies and regions lying further apart. This author studied the fauna Monogenea in three species of fish from the Mediterranean Sea, Adriatic Sea and the Baltic Sea. She found that fish from the Baltic Sea showed a complete lack of parasites from this group and came to the conclusion that the environmental conditions, and particularly the low level of salinity, in this water body do not make it possible for the species of Monogenea which are characteristic for fish from other marine reservoirs to live there. Similarly, the studies of Mamaev and Baeva (1962-63) included the global parasitic fauna of mintai (Theragra chalcogramma) and encompassed quite different regions. These authors collected material from the Sea of Okhotsk and

the Pacific Ocean near the coast of Kamchatka. They observed a higher degree of infection with 5 species of parasites in the sample of fish from the Pacific, while two species were noted considerably more often in individuals from the Sea of Okhotsk. Mamaev and Baeva suppose that there are two different colonies of mintai near the coast of Kamchatka, one of which lives in the Sea of Okhotsk and the other in the coastal waters of the Pacific. Zubchenko (1981) also presented interesting results. He carried out studies on Coryphaenoides rupestris (Macrouridae) from several fisheries in the North Atlantic along the coast of North America and Europe, and from the central part of this body of water (from the edge of the North Atlantic). He found that there was distinct differentiation in the degree of infection in fish even though common parasites were simultaneously present in all the examined regions. On the basis of this, I can draw conclusions about the formation of local colonies of this host and their migrations. 68/

The examples of studies given above approximate my studies in principle even though they encompass completely different host species of fish and deal with other water reservoirs or areas. These studies contain discussions of parasitic fauna formed in different regions; the observed differences are most often explained by different environmental conditions. The findings of these authors confirm my results to a certain extent and point out the differentiation of parasitic fauna in two populations of

blue halibut originating from areas of the North Atlantic which are very removed from one another and which undoubtedly differ ecologically.

4.4. An Attempt to Compare the Parasitic Fauna of Blue Halibut from Regions of the North Atlantic and Pacific

Studies of blue halibut from the North Pacific were conducted by Mamaev et al. (1963) and dealt only with helminth fauna. They found a total of 21 species of parasites in the coastal waters of Kamchatka. I found 13 of these in the examined individuals of blue halibut from the western part of the Bering Sea, while the remaining 8 species were not found in the material collected from this region. These were the trematodes Bucephalopsis gracilescens, Podocotyle atomom, Stenacron vetustum, Lecithaster gibbosus and Genarchopsis mülleri and the tapeworms Eubothrium sp., Bothriocephalus sp. and larvae Pseudophyllidea gen. sp. Most of the parasites in this list are species which very rarely occurred in the examined fish. These authors found that only L. gibbosus (27% infected) and S. vetustum (18%) occurred with a somewhat higher frequency. On the other hand, the following parasites, which were not found in this host by the authors mentioned above, were discovered in the examined individuals of blue halibut in my material from the Bering Sea: the protozoa Ceratomyxa drepanopsettae, Myxidium incurvatum and Paramyxoproteus reinhardti, larvae of the tapeworm Grillotia

erinaceus, the trematode Hemiurus appendiculatus and the crustacean Hatschekia sp. Moreover, the trematodes Aporocotyle simplex and the crustacean Acanthochondria sp. were also found in my material; these parasites were not noted by Mamaev et al. Nevertheless, the trematode A. simplex was noted in blue halibut from the Bering Sea by earlier researchers (Thulin, 1980). On the other hand, Kabata (1987) described crustaceans of the order Acanthochondria from the Pleuronectidae in the North Pacific. However, the individuals he found occurred on other hosts - Hippoglossus stenolepis and Hippoglossoides elassodon. 69/

The results obtained from studying the parasitic fauna of blue halibut from the Bering Sea may not completely reflect the state of infection of this host in this region due to the small number of fish examined. In spite of this, it is possible to notice some quite distinct differences when comparing these results with data from fishing grounds of the North Atlantic, particularly with respect to more frequently occurring parasites. The metacercariae of Stephanostomum baccatum and the crustacean Hatschekia sp. found in individuals of blue halibut from the Bering Sea were not found in fish from both North Atlantic fishing grounds (Tab. 2). Another species - Nybelinia surmenicola, one of the most common parasites of blue halibut in the Bering Sea - occurred only sporadically in fish from the Barents Sea and was not found at all in the Labrador region. There were also differences in the degree of infection. Blue halibut from

the Bering Sea showed a decidedly higher degree of infection with the nematode Phocanema decipiens and the acanthocephalon Echinorhynchus gadi in comparison with fish from the North Atlantic (Tab. 2 and 7). The studies of Mamaev et al. (1963) confirm my observations on the occurrence of S. baccatum, N. surmenicola, Ph. decipiens and E. gadi in individuals of blue halibut from the North Pacific. Studies carried out by Polyanskii (1955), Zubchenko (1980) and Reimer (1981) also show that metacercariae of S. baccatum and plerocercoids of N. surmenicola were not noted in this host in the North Atlantic.

The crustacean Neobrachiella rostrata is also noteworthy as it occurred quite frequently in my material in fish from both fishing grounds in the North Atlantic (Tab. 2 and 7). Reimer (1981) also noted the presence of this species in blue halibut in the Davis Strait and near Bear Island. Moreover, Rokicki (1982) mentions this species in blue halibut from the Labrador fishing grounds. On the other hand, this crustacean was not found in blue halibut from the North Pacific. These observations are confirmed to a certain extent by studies done by Kabata (1979), who noted N. rostrata on white halibut only in the North Atlantic. The rare parasites found in my material from the Bering Sea included the trematodes Aporocotyle simplex and Hemiurus appendiculatus, and the crustacean Acanthochondria sp. (Tab. 2 and 7). These species were not found in my material from the vicinity of Labrador and the Barents Sea. Other researchers

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(Polyanskii, 1955; Zubchenko, 1980; Reimer, 1981) did not find them in blue halibut from the North Atlantic, either. The available literature shows that the trematode Hemiurus appendiculatus and the crustacean Acanthochondria sp. mentioned here have not been found at all in blue halibut to date.

The differences in infection with parasites of blue halibut from the North Atlantic and Pacific regions given above suggest that the parasitic fauna of this host from fishing grounds in the North Pacific has certain distinct characteristics. This is evident mainly in the composition of parasitic species. Quantitative differences are more difficult to observe due to the small number of examined fish from the Bering Sea. Nevertheless, these differences are quite distinct in the case of some species. These observations require verification and should be based on a larger amount of material.

4.5. Parasites of Blue Halibut which are Pathogenic for Humans

The individuals of blue halibut from the North Atlantic and Pacific in my material contained two species of parasites which are pathogenic for humans. These are larvae of the nematodes Anisakis simplex and Phocanema decipiens. Infection in humans takes place after eating fish which contain third-stage invasion larvae of these parasites.

The first cases of serious illnesses of the alimentary canal caused by Anisakis larvae were diagnosed in Holland in 1955

(Van Thiel et al, 1960). After this discovery, many subsequent confirmations were reported, particularly in Japan (approx. 500 cases up to 1968) where many dishes of raw fish are traditionally eaten (Kagei, 1968). This disease started to be referred to as anisakidosa. According to Margolisa (1977), a total of 1200 cases of human infection with this nematode have been noted on different continents with the last 15 years. A large number of illnesses were discovered during operations. Nonetheless, many cases have undoubtedly not been included in statistics due to erronous diagnoses since the clinical symptoms of anisakidosa are not specific and may indicate other abdominal illnesses. The strongest symptoms occur in patients within 24 to 48 hours after eating fish infected with larvae of Anisakis (Kagei, 1968), yet their presence was already noted in some case within 4 - 6 hours. Symptoms consist of severe stomach pain, nausea, vomiting, diarrhea, and sometimes an increase in temperature or irritation and swelling of the throat (Kagei, 1968; Grabda, 1973b; Prokopowicz, 1986). 71/

Once in the alimentary canal, larvae of Anisakis penetrate into the mucous membrane completely, and occasionally into the submucous membrane of the stomach or the intestine. Quite often, only their front end penetrates into the intestine wall, while the rear part of the nematode hangs towards its lumen (Van Thiel et al., 1960). Edema, hyperemia, erosion or ulceration of the mucous membrane occur in the area of larval penetration

(Van Thiel et al., 1960; Yokogawa i Yoshimura, 1967; Prokopowicz, 1986). Granulomatous changes causing reduction of the stomach or intestinal lumen have also been noted (Prokopowicz, 1986). Histological investigations showed that extensive infiltration of eosinophilic leukocytes with histiocytes, neutrophiles and lymphocytes appears around the parasites embedded in the mucous membrane (Van Thiel et al., 1960; Yokogawa and Yoshimura, 1967).

Larvae of the nematode A. simplex do not reach sexual maturity in the human organism. However, one moulting does take place which gives rise to the fourth stage of development (preadult). The larvae survive for 3 - 4 months after which they atrophy (Van Thiel et al., 1960; Yokogawa and Yoshimura, 1967).

According to my material, infection with larave of A. simplex in blue halibut was particularly high in the Barents Sea and the Bering Sea (Tab. 2). The average degree of infection in the population reached 272.42 larvae in one examined fish from the Barents Sea, while this figure reached 917.00 nematodes in the Bering Sea. A significantly lower degree of invasion with this species was noted in blue halibut from the vicinity of Labrador and averaged 0.68 larva per fish (Tab. 7). Most of the parasites established themselves in the host's body cavity (Tab. 3). However, a certain number were present in muscles: 6.9% of the larvae in individuals from the Barents Sea, and 9.5% of the larvae in fish from the Bering Sea.

Studies carried out by Van Thiel et al. (1960) and Vika (1964) show that larvae of A. simplex moved from the body cavity to the muscles of hosts a few hours after the fish were caught. 72/ For this reason, the gutting of blue halibut on the fishing vessel immediately after the fish are caught seems to be advisable. This pertains particularly to fishing grounds where there is a high nematode invasion. Moreover, other methods should be used which kill larvae of A. simplex and are mandatory in the fish industry in order to protect humans from infection. One of the fundamental methods is freezing the fish to a temperature of $-20^{o}C$ within 12 hours and keeping them at that temperature for a minimum of three days. The author thinks that blue halibut can be sent for further processing only after this treatment.

Larvae of the second pathogenic species - Phocanema decipiens - have been found in the alimentary canal of humans with considerably less frequency. According to Margolis (1977), a total of 50 cases of human infection have been reported in the most recent period of time with most of them occurring in Japan (37 cases) and the USA (6 cases). The cause of illness was the consumption of raw fish; Pacific halibut (Hippoglossus stenolepis) was among them. In most of the noted cases, the patients experienced severe pains in the epigastrium area combined at times with nausea and vomiting or other abdominal disorders. Pains appeared from 2 to 10 hours after eating raw marine fish and recurred with breaks every 3 to 10 minutes (Suzuki et al., 1972;

Margolis, 1977). These disorders were connected with the penetration of Phocanema larvae into the mucous membrane of the stomach. The nematodes penetrated into the stomach wall with the front part of their body; inflammation of the mucous membrane, edemae and hyperemia formed around these areas. Clinical symptoms took place up until the larvae were removed from the stomach (sometimes up to 10 days), following which the pains abated after a few hours or days and the patients regained their health. Invasions with larvae of this species rarely occurred without symptoms. In such cases, the nematodes were present in the stomach lumen and did not penetrate into the mucous membrane (Margolis, 1977). As is the case of A. simplex, Ph. decipiens does not reach sexual maturity in the alimentary canal of humans (Grabda, 1981).

The level of infection with Ph. decipiens larvae in blue halibut was considerably less as compared to that of A. simplex. However, infection with this parasite was found in 50.9% of the examined individuals from the Barents Sea, while fish from the Bering Sea were 100% infected. The average degree of infection in the population of these bodies of water was 2.34 and 6.29 larvae per fish, respectively (Tab. 7). The decidedly greatest number of Ph. decipiens larvae found in blue halibut individuals from the Bering Sea occurred in muscles, whereas larvae in fish from the Barents Sea were concentrated mainly in the liver (Tab. 3). Blue halibut from some fishing grounds may therefore

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constitute a serious source of human infection because of this parasite. The cases of Ph. decipiens invasion in humans described to date indicate that they take place in a milder form than in the case of infection with A. simplex. Moreover, Croll et al. (1980) have concluded that, based on experimental research on rats, Ph. decipiens larvae are of lesser pathogenic significance for an undamaged alimentary canal in humans. In spite of this, the same methods as in the case of A. simplex should be used to protect humans from being infected with this species.

In addition to the parasites enumerated above, the nematode Thynnascaris adunca should also be mentioned since a case of human infection with third-stage larvae was reported in France following the consumption of sardines containing larvae of this species (Petter, 1969). According to this author, they can cause eosinophilic granuloma in humans. Third-stage Th. adunca larvae occurred quite often in my material (Tab. 2). The average degree of infection in the blue halibut population in individual fishing grounds reached 3.77 - 43.00 larvae in one fish (Tab. 7). They were present on various organs in the body cavity, and in individual cases they were also found in muscles (Tab. 3). It is therefore not possible to rule out the possibility of humans becoming infected with this parasite after eating blue halibut.

Of the remaining parasites found in the blue halibut contained in my material, acanthocephalon larvae of the order Corynosoma should also possibly be treated with a certain amount

of caution. Schmidt (1971) described the discovery of a young form of C. strumosum in human feces in Alaska.

Studies carried out by Nuorteva (1966) show that C. strumosum and C. semerme larvae are pathogenic for mink fed with raw marine fish. This author observed inflammation in the end portion of the small intestine of the mink where numerous acanthocephalons were present. Moreover, along with invasion with these larvae, the author also noted symptoms of anemia, dysenteric diarrhea and individual mortal cases. Both species of acanthocephalons - C. strumosum and C. semerme - were found in blue halibut. One of them - C. strumosum - was a common parasite in fish from the Barents Sea (Tab. 2 and 7). These parasites were present in the body cavity and, in one case only, an encysted larva was found in the muscles (Tab. 3). Because of this, these parasites do not constitute a great threat for humans but their presence as well as the presence of Thynnascaris adunca larvae in this host should be noted. Utilization of the deep freezing techniques suggested in the treatment of Anisakis simplex also causes these parasites to be killed. Gutting of fish immediately after they have been caught is also advisable as this removes most of the nematode and acanthaphalon larvae.

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5. SUMMARY AND CONCLUSIONS

1. There were 19 species of parasites found in individuals of blue halibut (Reinhardtius hippoglossoides (Walbaum, 1792)) in

the vicinity of Labrador. Of these, the following were the most significant with respect to incidence and degree of infection: Ceratomyxa drepanopsettae, Paramyoproteus reinhardti and Myxidium incurvatum (Protozoa), Scolex pleuronectis (Cestoda), Stenacron vetustum and Derogenes varicus (Trematoda), and Thynnascaris adunca (Nematoda).

2. There were 18 parasitic species found in fish from the fishing ground in the Barents Sea. The following showed the highest level of infection in blue halibut from this body of water: Ceratomyxa drepanopsettae, Paramyxoproteus reinhardti, Scolex pleuronectis, Derogenes varicus, Thynnascaris adunca, Anisakis simplex (Nematoda) and Corynosoma strumosum (Acanthocephala).

3. The total number of parasitic species found by me in individuals of blue halibut from the North Atlantic (fishing grounds off Labrador and in the Barents Sea) was 22 and was higher in relation to data from the available literature.

4. Only a small number of parasites showed a tendency to increase in number along with fish age. Statistical analysis shows that this increase was significant only in the case of Anisakis simplex, which is closely connected to the biology of both the host and this nematode.

5. A common characteristic of the parasitic fauna of blue halibut from the vicinity of Labrador and the Barents Sea was the domination of the protozoa Ceratomyxa drepanopsattae and

Paramyxoproteus reinhardti. The intensity of occurrence of these parasites was similar in both fishing grounds.

6. The parasitic fauna of blue halibut from the aforementioned regions of the North Atlantic has its own largely distinct character. The following differences were noted: Phocanema decipiens and Corynosoma semerme (Acanthocephala) were found only in fish from the Barents Sea, whereas Steganoderma formosum (Trematoda) was found exclusively in the Labrador fishing grounds. Moreover, C. strumosum, which commonly lives in this host in the Barents Sea, almost never occurred in fish from the vicinity of Labrador. 75/

7. Fish from the Barents Sea were infected to a greater (statistically significant) degree with the majority of Metazoa species which are common to both regions. These included: Scolex pleuronectis, Derogenes varicus, Fellodistomum furcigerum and Hemiurus levinseni (Trematoda), Anisakis simplex and Thynnascaris adunca, as well as Neobrachiella rostrata (Crustacea).

8. Significantly higher levels of infection in blue halibut from the vicinity of Labrador were found only in the case of Stenacron vetustum and Lecithaster gibbosus (Trematoda), as well as Echinorhynchus gadi (Acanthocephala). Myxidium incurvatum and Ortholinea divergens (Protozoa) also predominated in this region in comparison with levels of infection in fish from the Barents Sea.

9. The parasitic fauna of blue halibut from fishing grounds in the Bering Sea described here was composed of 21 species. The following were frequent parasites in fish from this area: Ceratomyxa drepanopsettae, Nybelinia surmenicola (Cestoda), Stephanostomum baccatum (Trematoda), Anisakis simplex, Thynnascaris adunca, Phocanema decipiens and Echinorhynchus gadi.

10. Differences in species were observed between parasites occurring in fish from fishing grounds in the North Atlantic and Pacific. Among other things, Stephanostomum baccatum and Hatschekia sp. (Crustacea) were found only in blue halibut from the Bering Sea. Similarly, Nybelinia surmenicola, one of the most common parasites of this host in this area, was found only sporadically in the Barents Sea. The quantitative differences between some parasites require verification using more material.

11. The presence of the following parasites was discovered for the first time in blue halibut: the protozoan Myxidium incurvatum, the trematode Hemiurus appendiculatus, and the crustacean Acanthochondria sp.

12. Certain inconsistencies were shown in the shape and dimensions of Ortholinea divergens spores found in fish examined for this study in comparison with descriptions given by other authors. The presence of the following were noted in blue halibut: protozoa of the species Ceratomyxa drepanopsettae and a new species and genus described earlier by the author - Paramyxoproteus reinhardti. On the other hand, the protozoa Schulmania 76/

quadriolobata and Myxidium sphaericum given in the literature were not found in blue halibut.

13. A number of parasites of blue halibut from the North Pacific were found that had not been noted earlier by other authors, namely Ceratomyxa drepanopsettae, Myxidium incurvatum, Paramyxoproteus reinhardti, Grillotia erinaceus (Cestoda), Hemiurus appendiculatus, Hatschekia sp. and Acanthochondria sp.

14. A parasitic crustacean of blue halibut which is most likely a new species was noted. Morphologically, it approximates Hatschekia hippoglossi from white halibut. The crustaceans found in this study differed from this species by several enumerable characteristics, among other things.

15. Two species of nematodes which are pathogenic for humans were found in fish from fishing grounds of the North Atlantic and Pacific. These were the larvae of Anisakis simplex and Phocanema decipiens. The greatest number of A. simplex larvae were found in blue halibut from the Bering Sea, where the average degree of infection in the population was as many as 917 nematodes in one fish. The largest average incidence of infection with Ph. decipiens was also found in the fish population from the same body of water; this figure reached 6.29 individuals in one fish.

16. Places where both species of the parasites which are pathogenic for humans were found included the muscles, liver and gonads of the examined fish. Blue halibut can therefore be a serious source of infection for humans.

17. Larvae of the nematodes Thynnascaris adunca, and larvae of the acanthocephalons Corynosoma strumosum and C. semerme are among the remaining parasites found in halibut which can also pose a certain threat to humans. However, infection with these parasites occurs very seldomly in humans.

18. The author proposes that the entrials of blue halibut be removed from the body cavity immediately after the fish are caught and that deep freezing of the fish be carried out in order to protect humans from infection with the above parasites.

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